S. HRG. 109–896

OVERSIGHT ON THE NUCLEAR REGULATORY COMMISSION

HEARING

BEFORE THE

SUBCOMMITTEE ON CLEAN AIR, CLIMATE CHANGE, AND NUCLEAR SAFETY

AND THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
UNITED STATES SENATE

ONE HUNDRED NINTH CONGRESS

FIRST SESSION

MAY 26, 2005

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ONE HUNDRED NINTH CONGRESS

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C O N T E N T S

HEARING TO CONDUCT OVERSIGHT ON THE NUCLEAR REGULATORY COMMISSION

THURSDAY, MAY 26, 2005

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
SUBCOMMITTEE ON CLEAN AIR, CLIMATE CHANGE AND NUCLEAR SAFETY,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:00 a.m. in room 406, Senate Dirksen Office Building, Hon. George V. Voinovich (chairman of the subcommittee) presiding.

Present: Senators Voinovich, Inhofe, Isakson, Jeffords, Carper, Lautenberg, and Obama.

Senator VOINOVICH. The hearing will come to order.

Good morning, and thank you all for coming. I will give a short statement, and would encourage other members to do the same, as everyone's statements will be inserted into the record.

OPENING STATEMENT OF HON. GEORGE V. VOINOVICH, U.S. SENATOR FROM THE STATE OF OHIO

Today's hearing continues this committee's strong oversight of the Nuclear Regulatory Commission. This is the seventh in a series of oversight hearings that began in 1998, when Senator Inhofe was chairman of this subcommittee. This committee is very busy on nuclear issues this year. We held a nominations hearing in April and a closed nuclear security session last week.

I welcome back the commissioners. I understand that Commissioner Merrifield cannot be here today due to a family commitment, and I send my thoughts and prayers to Mr. Lyons and his family, who also could not be here today because of a family medical situation.

At last week's hearing we addressed nuclear security, as well as many other issues, and I wish that many of my colleagues had been there, because we went beyond the security issues and got into some of the things that we are probably going to get into today. So you may get some questions on some of the things we already discussed, but it is important that the committee hear from you on those issues.

Although the Commission has made significant progress in the area of security, they need help from us in Congress. You need help. Chairman Inhofe and I have introduced S. 864, the Nuclear Safety and Security Act of 2005, which includes provisions that you have requested for many years. Since last week's hearing focused

solely on security, I encourage members and the witnesses to focus on non-security issues as much as possible today.

Chairman Inhofe and I have also introduced the Nuclear Fees Reauthorization of 2005 and the Price-Anderson Amendments of 2005, S. 865.

I want to thank you, Senator Carper, for co-sponsoring these 2 pieces of legislation.

S. 858 reauthorizes the current fee requirement that expires on September 20, 2005. That requirement says that the industry itself has to pay 90 percent of the fees, and if we don't pass this legislation, it slips back to their paying 35 percent of the costs, to my understanding. It also contains several NRC reform and human capital provisions which are very, very important for the Commission to get the job done that we are asking you to do. You can't do it unless you have the staff and the team to get the job done, and if we don't get this taken care of, you are not going to be in a position to do that.

The third bill, 865, reauthorizes the Price-Anderson Act—we have been doing that now for, what, 3 or 4 years—which for 45 years has provided a proven framework of liability protection for the public should a nuclear accident occur.

Several staff briefings have occurred on the issues addressed by these bills and bipartisan negotiations are occurring on a daily basis. I encourage members to let us know of any issues or concerns with these 3 pieces of legislation. As I understand it, the Chairman intends to mark them up on June the 8th.

I thank everyone for attending this very important oversight hearing. The NRC and the industry must keep safety at the center of all these things that they do, and we are going to continue to have these oversight hearings just to kind of touch base with you periodically.

[The prepared statement of Senator Voinovich follows:]

STATEMENT OF HON. GEORGE V. VOINOVICH, U.S. SENATOR FROM THE STATE OF OHIO

The hearing will come to order. Good morning and thank you all for coming.

Today's hearing continues this Committee's strong oversight of the Nuclear Regulatory Commission. This is the seventh in a series of oversight hearings that began in 1998 when Senator Inhofe was chairman of this Subcommittee. I thank the Chairman for his leadership on this issue as strong oversight of the NRC is critical to the welfare of the American public.

I am a strong advocate of nuclear power because it plays a critical role in meeting our nation's energy, economic, and environmental needs. Ensuring that our nuclear power plants are safe and secure is absolutely essential if we plan to continue and hopefully increase our nation's use of this valuable energy source.

This Committee is very busy on nuclear issues this year. In April, we held a nominations hearing where the Commission's two newest members testified. I welcome you—Mr. Jaczko—back this morning and send my thoughts and prayers to Mr. Lyons and his family who could not be here due to a family medical issue.

I also welcome back Chairman Diaz and Commissioner McGaffigan who testified last week at our closed nuclear security hearing. I found that hearing to be extremely informative because it allowed us to have a frank discussion about nuclear security.

I am pleased with the Commission's work on security enhancements, strengthened control access, and development of a supplemental design basis threat. These actions have increased the number of guards at power plants by 60 percent—from around 5,000 to around 8,000 guards—and required the nuclear industry to make physical improvements at every plant to a tune of $1.2 billion industry-wide.

We here in Congress now need to do our part. Chairman Inhofe and I have introduced S. 864, the Nuclear Safety and Security Act of 2005, which includes provisions that the NRC has requested for many years on weapons, fingerprinting, and Federal crimes. Since last week's hearing focused solely on security, I encourage members and the witnesses to focus on non-security issues today.

Chairman Inhofe and I have also introduced the Nuclear Fees Reauthorization Act of 2005 (S. 858) and the Price-Anderson Amendments Act of 2005 (S. 865). I thank Senator Carper for cosponsoring these two pieces of legislation.

We need to address the current fee requirement, which must be reauthorized by September 20, 2005. If this fee requirement expires, the Commission will only be allowed to collect 33 percent of their fees from licensees with the remaining amount coming from the Treasury. S. 858 allows the Commission to continue to recover 90 percent of its costs through licensee fees.

This bill also contains several NRC reform and human capital provisions—many of which have passed this Committee and the Senate in the past. As the Commission's workload increases over the next few years due to the next generation of nuclear power plants, re-licensing, increased security oversight, and Yucca Mountain activities, I am increasingly concerned about the availability of qualified personnel. Where are we going to find the necessary reactor engineers, shielding engineers, reactor and environmental health physicists, licensing specialists, etc? We learned at last week's hearing that the Commission will be at least 300 personnel short in critical areas by 2007 and this does not even address the yearly attrition of 200 personnel.

S. 858 contains provisions to attract young technical college students via internships, co-op programs, and fellowships by providing incentives. It also allows the Commission to hire retirees as contractors, exempting them from the annuity reductions that would otherwise apply.

The third bill would reauthorize the Price-Anderson Act, which for 45 years has provided a framework of liability protection for the public should a nuclear accident occur. Given this proven record, I encourage my colleagues to renew the law as outlined in S. 865.

Several staff briefings have occurred on the issues addressed by these bills and bipartisan negotiations are occurring on a daily basis. I encourage members to let us know of any issues or concerns with these three pieces of legislation, as I understand that the Chairman intends to mark them up on June 8.

Finally, I thank the Commission for their focused scrutiny of the Davis-Besse nuclear plant over the past 3 years. Last week, the NRC terminated its special Oversight Panel which is a sign of the significant progress that the plant has made. I commend the NRC, the operator, and its employees for their hard work. However, I continue to expect that the lessons-leaned during their special reviews will be fully implemented not only at Davis-Besse but throughout the industry. With this in mind, I am concerned about recent developments at the Perry nuclear plant and look forward to discussing them with you today.

I thank everyone for attending this very important oversight hearing. The NRC and the industry must keep safety as the center of all that they do, and I will continue to conduct strong oversight as Chairman of this Subcommittee to make sure that remains the case. I look forward to working with my colleagues to pass needed legislation early next month.

Thank you.

Senator Carper.

OPENING STATEMENT OF HON. THOMAS R. CARPER, U.S. SENATOR FROM THE STATE OF DELAWARE

Senator CARPER. Thank you, Mr. Chairman. Thanks for holding the hearing.

To our witnesses, thank you for joining us and for your service.

We gather here today when our dependence on foreign oil continues to grow; it approaches some 60 percent of the oil that we consume comes from other sources. We gather at a time when our Nation's trade deficit now exceeds, I think, about $700 billion per year. About a quarter of that is related to our dependence on foreign oil.

We gather here at a time when emissions of sulfur dioxide, nitrogen oxide, mercury are fouling our air and harming our health.

And we gather here at a time when enormous amounts of carbon dioxide are being emitted into the air and, I think, threaten the warming of our planet, with dire consequences, maybe not for us, but for our children and for our grandchildren.

There is no silver bullet to remedy all of those ills, but one of the important arrows in our quiver, if I can mix metaphors, is safe, dependable nuclear energy to generate the electricity that we consume in this country.

The one sure way to reduce the likelihood that nuclear energy can be a growing part of the strategy to meet our electricity needs is for a lapse in safety to lead to an incident at one of our nuclear power plants. Anything approaching a Three Mile Island would set us back another 10, 20, 30 years. One of the best ways to make sure that that doesn't happen is for all of us to be vigilant; for those folks who are running the nuclear power plants, for their management, obviously for this Commission, and for those of us who are in power to oversee the work that you do.

Chairman Diaz and I, and perhaps other members of the Commission, were present last week at an event hosted by the Nuclear Energy Institute, and in my comments, Mr. Chairman and colleagues, I spoke of zero tolerance. I spoke of the absolute commitment to doing everything well. If we take that spirit, go forward with that spirit, we will be better, safer as a country and I think we will be more secure in more ways than one.

The last thing I would say, Mr. Chairman, thank you for introducing the legislation that you have. I am pleased to join you as a co-sponsor in two of the three bills, and hope to join you as a cosponsor in the third as we work through the remaining differences that we have there. I, frankly, very much appreciate the approach that is being taken to resolve the remaining differences with the third piece of legislation.

That having been said, I am pleased to be here. We look forward to hearing from our witnesses. Thank you.

Senator VOINOVICH. Thank you, Senator Carper.

Senator Jeffords.

OPENING STATEMENT OF HON. JAMES M. JEFFORDS, U.S. SENATOR FROM THE STATE OF VERMONT

Senator JEFFORDS. Thank you, Mr. Chairman.

Today's hearing continues our ongoing oversight of the Nuclear Regulatory Commission. I believe this is the seventh oversight hearing the subcommittee has held in the last 8 years. Chairman Voinovich, you and ranking member Carper deserve credit for continuing the commitment to hold these hearings regularly in order to review the NRC's activities.

Today, I want to discuss the Commission's follow-up on an incident involving the missing pieces of fuel rods at the Vermont Yankee Nuclear Power Plant in my State. The Government Accountability Office is here today to discuss the results of the study that was completed on this issue at my request. I am pleased with their work and with their close attention to the concerns of Vermont and Massachusetts delegation in drafting it.

I appreciate too that Chairman Diaz has always been willing to discuss my concerns with operational and safety issues at the

Vermont Yankee with me directly. I also want to say to the chairman and all the commissioners present that I am pleased you are all here today. Good to see you all.

The mission of the NRC is one of the most vital missions carried out by the Federal Government. Regulating the Nation's civilian use of nuclear materials, ensuring adequate protection of public health and safety when these materials are used or disposed of, and protecting the environment are all very critical. I want to make myself perfectly clear—and I know that the Chairman and the Ranking Member of the subcommittee share my view—the top priority for the NRC is safety. There is no greater issue than safety. I want my Vermont constituents and people across the country to be safe, and it is the NRC's job to guarantee it.

As you are all aware, last year there were some serious problems at Vermont Yankee, which I discussed at length in the last oversight hearing. Vermont Yankee, operated by Entergy, discovered that two pieces of radioactive fuel rods were missing from the plant's storage facility. Either was capable of quickly giving a lethal dose of radiation to an unshielded handler.

Though the materials were found to have never left the plant, and were in the spent fuel pool, the search to locate these materials raises serious questions about whether NRC is conducting the appropriate oversight of nuclear materials at individual nuclear plants and whether the Federal Government should change its nuclear materials management policies.

The loss of the fuel rods at Vermont Yankee was the second incident of missing fuel rods at a Northeastern nuclear plant in the last 5 years. When the Millstone incident occurred, the NRC said that the fuel rods had never before gone missing in the history of the commercial nuclear power in the United States. While I know that the materials at Vermont Yankee were found to be missing due in part to the new inspection procedures that the NRC institutes after Millstone, the sad fact is that the fuel again went missing. We must improve our nuclear materials accounting system. We must do it now, and I hope that the GAO's work is the first step in drafting better materials accounting legislation.

If we are going to be serious about protecting our environment while providing safe, reliable, and affordable electricity for all Americans, we need to increase our use of renewables, improve how we burn fossil fuels, and promote energy efficiency and make certain that the nuclear plants operate well and safely.

Again, I want to thank Chairman Diaz, the rest of the commissioners, and the other witnesses who are coming here to discuss these issues today. I look forward to hearing their testimony, Mr. Chairman. Thank you.

[The prepared statement of Senator Jeffords follows:]

STATEMENT OF SENATOR HON. JAMES M. JEFFORDS, U.S. SENATOR FROM THE STATE OF VERMONT

Thank you Mr. Chairman, today's hearing continues our ongoing oversight of the Nuclear Regulatory Commission. I believe this is the seventh oversight hearing the Subcommittee has held in the last 8 years. Chairman Voinovich, you and Ranking Member Carper deserve credit for continuing the commitment to hold these hearings regularly in order to review the NRC's activities.

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If we are going to be serious about protecting our environment while providing safe, reliable, and affordable electricity for all Americans, we need to increase our use of renewables, improve how we burn fossil fuels, promote energy efficiency, and make certain that nuclear plants operate well and safely.

Again, I thank Chairman Diaz, the rest of the Commissioners, and the other witnesses for coming here to discuss these issues. I look forward to their testimony and to working with my colleagues.

Senator VOINOVICH. Thank you, Senator Jeffords.

Senator Lautenberg.

OPENING STATEMENT OF HON. FRANK LAUTENBERG, U.S. SENATOR FROM THE STATE OF NEW JERSEY

Senator LAUTENBERG. Mr. Chairman, thanks for convening this hearing.

This is being forced on us by the reality of life, whether or not we are going to be blackmailed by those who produce fossil fuels that we import, whether it is the assault on the environment, or whether or not we can realistically be assured that safety with nuclear plants is obtainable.

In my home State of New Jersey there is much concern about our three nuclear plants. We get more than half of our electric power from them, so the mission of the Nuclear Regulatory Commission is extremely important to me. It is critical in the economy of our region and our country, and I believe that it can make increasing contribution to our Nation's growing energy needs.

By the way, for those who might hear Frank Lautenberg talking now and say you talk on both sides of your mouth, Senator, because there were times in the past when I thought that nuclear energy was a bad idea; we had abandoned two major plants at bil-

lions and billions of dollars worth of cost, because of escape route limitations. We change as time goes by and recognize that nuclear energy is required as one of the alternative sources for energy production, but we also have to be assured that we can do it with safety. Safety doesn't begin with the production, it begins also with the conclusion of a plant's ability or the fuel that it has to be disposed of and stored safely.

So, Mr. Chairman, I am pleased that you are doing this.

I mentioned to our commissioners, I thank you for the work you do. It is public service, in my view, at the very highest level, and it by no means is an easy assignment. We recognize that when we have placed new commissioners on the team, and the difficulty it had getting assurances, etc. You do good work and we congratulate you for it. We only want you to do more good work. The Oyster Creek Nuclear Plant in New Jersey is the oldest operating facility in the country and I hear regularly from my constituents who live near the facility about their safety concerns. There is a question about whether Oyster Creek ought to be licensed, so it is absolutely essential that we turn to the NRC for factual, unbiased data. There have also been concerns about our other plants, Salem and Hope Creek Nuclear Power Plants, and we all depend, again, on the NRC to enforce a culture of safety at every nuclear facility.

Lastly, we must come up with a safe, feasible solution to the problem of nuclear waste. Not an easy problem to solve, obviously. Dry cast storage may be the best we have at this time, but we have to continue to look pass what we have at this time and look for new ways to do it.

Mr. Chairman, I am sorry that I can't stay for this hearing. I consider it important, but, unfortunately, I have 3 important hearings at the same time. So I wish our witnesses well, and I know that they will be energetically reviewed by my colleague from Delaware, as well as Vermont, and the Chairman. Thank you.

[The prepared statement of Senator Lautenberg follows:]

STATEMENT OF HON. FRANK LAUTENBERG, U.S. SENATOR FROM THE STATE OF NEW JERSEY

Mr. Chairman, thank you for holding this hearing and giving us the opportunity to learn about the energy project permitting process. I look forward to hearing from all of our witnesses. Former President Richard Nixon was a man who made a lot of political enemies. In fact, I was on his official 'enemies list' during the time when I was CEO of a major company.

As we look back today, I think we all acknowledge that despite his many enemies, Richard Nixon was in many ways a friend of the environment. It was during his presidency that our nation made a commitment to cleaning up our air and water, with the landmark Clean Air Act and Clean Water Act.

It was during his Republican Administration that we created the Environmental Protection Agency. And it was President Nixon who signed the National Environmental Policy Act (NEPA) which required Environmental Impact Statements for major projects like roads and drilling for natural gas. Since then, five presidents of both parties have continued the legacy of protecting our environment, and honoring the right of citizens and states to have a voice in the process.

Unfortunately, the current Administration has chosen not to follow that path. This Administration seems especially sympathetic to complaints about regulatory processes that were put in place to protect our environment and health.

While, I am always willing to look for ways to improve efficiency, effectiveness and fairness in our rules and laws, I see no reason to backtrack from our commitment to ensure that citizens have a strong voice in matters that affect our environment.

NEPA—and the role it gives to citizens—is one of the best manifestations of democracy in our country. We must not erode NEPA's protections or silence the voice of Americans, especially in projects that affect their own communities.

Yes, environmental reviews cost money—and energy companies can afford it. To take just one example, ExxonMobil's profits increased by 44 percent in the last quarter!

We can—and we should—look for ways to improve and perhaps streamline our processes for granting permits for vital projects. But we must never allow the convenience of corporations to trample the rights and the health of the American people.

Senator VOINOVICH. Thank you, Senator Lautenberg. You have been very diligent about your attendance at our hearings, and we appreciate it.

I am going to ask permission to have my entire opening statement inserted in the record. Without objection, it will be put in the record.

Chairman Diaz, Commissioner McGaffigan, and Commissioner Jaczko, it is nice to see you again. I greatly appreciate your coming here today for our annual NRC oversight hearing, and I really appreciate your candor and straightforwardness at the closed session that we had.

Due to time constraints this morning, I am going to ask only Chairman Diaz to give an opening statement. Of course, if someone wants to chime in after Chairman Diaz about something, I would welcome that. But we will ask you for an opening statement, and if you could keep it to 5 minutes, we would be most grateful. As you know, the tradition is that your entire statement will be put in the record.

Chairman Diaz.

STATEMENT OF NILS J. DIAZ, CHAIRMAN, U.S. NUCLEAR REGULATORY COMMISSION

Mr. DIAZ. Thank you, Mr. Chairman and members of the subcommittee. It is a pleasure to appear before you today with my fellow commissioners to discuss the U.S. Nuclear Regulatory Commission programs.

The NRC continues to take an integrated approach to safety, security, and emergency preparedness in carrying out the mission chartered by the Congress. I will highlight our key ongoing oversight and licensing activities today.

The Reactor Oversight Process is being implemented with increasing effectiveness. Nuclear power plants continue to operate in a safe and secure manner. We have resolved most of the issues of manpower and communications related to oversight that the committee was concerned with last year. The Davis-Besse nuclear power plant has received attention and resources commensurate to the problems found and to the resolution. The plant has been operating safely and the NRC staff recently determined that plant performance warranted termination of the special panel that was created specifically for Davis–Besse oversight.

Reactor licensing program, coupled with a strong oversight program, ensures protection of public health and safety throughout a plant's operating life. I know that the NRC has, to date, renewed a total of 32 reactor licenses, has 16 under review, and has approved 105 power upgrades.

The industry has expressed interest in new construction of nuclear power plants. The NRC is prepared to discharge this responsibility if applications for new power plants are filed. We anticipate that applicants will utilize the licensing processes which were developed to provide a more stable, timely, and predictable licensing process. This includes the sign certification and early site permits which can be referenced in an application for a combined construction permit and operating license.

The Commission continues to conduct assessments and to impose new requirements, when appropriate, to enhance security of nuclear facilities and materials. The NRC is currently developing a proposed rule and supporting guidance to codify supplemental requirements, including the design basis threat. We are continuing to perform detailed nuclear power plant and spent fuel pool site-specific studies to further enhance our understanding of appropriate mitigative culpabilities and to ensure effective implementation of these culpabilities, including consideration of those recommended by the National Academy of Sciences. Thus far, the results of these assessments have validated the actions NRC has taken to enhance security.

The NRC, in partnership with 33 agreement States, conducts comprehensive programs to ensure the safe use of radiological materials in a variety of medical, industrial, and research settings. With regards to material security, the NRC has thoroughly re-evaluated its safeguards and security programs, and we are confident that appropriate measures are being implemented.

The NRC continues to ensure that the agency is prepared to review a potential application by DOE to construct a deep geologic high-level waste repository at Yucca Mountain, NV, and NRC stands ready to amend the regulations consistent with any forthcoming changes to the EPA standards. Also, storage and transport cask designs continue to be reviewed and certified.

The NRC carries out an active international program of corporation and assistance involving 38 countries with which it exchanges nuclear safety information. We just approved an export and import rule which will enable the United States to meet its goal with the G–8 to implement the IAEA Code of Conduct provisions by December of this year.

The NRC is very dependent on a highly skilled and experienced work force for the effective execution of its activities. NRC has developed an agency-wide set of strategic capital management strategies to mitigate and close gaps between available staffing resources and anticipated staffing needs. We greatly appreciate your support for NRC human capital and all the legislative proposals.

Mr. Chairman, we can assure you that the Commission continues to be committed to fulfilling its statutory role. We appreciate the support we have received from the committee and the subcommittee as a whole, and we will need your support in the days to come.

I would be pleased to respond to your questions.

Senator VOINOVICH. Thank you, Chairman Diaz.

Mr. Jaczko or Mr. McGaffigan, anything to add?

Thank you.

We are very fortunate that the chairman of this committee, the Senator who started this aggressive oversight, is here with us this morning. Senator Inhofe, we are interested in hearing from you in terms of a statement or questions or whatever it is that you would like to do this morning.

Senator INHOFE. First of all, I appreciate that, and I would like to go ahead and have a very brief opening statement. I have some very strong feelings about this and, of course, as the Chairman knows and as you know, Senator Voinovich, when I had the chairmanship of this subcommittee, we hadn't had an oversight hearing in 10 years or so, and we have come a long way. So if I could just make a couple of comments.

OPENING STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKLAHOMA

Well, I think I already said this. Since I became chairman of the subcommittee, we had not had an NRC oversight hearing in over a decade. The re-licensing process was estimated to take over 5 years per unit, if it could be completed at all. The NRC was more concerned about paperwork violations than real risk issues, and no one was even considering building a new nuclear unit.

Today, we have regular oversight hearings. The re-licensing process is being completed on time. I commend you for that. The NRC has moved to a risk-based climate and people are actually talking about new nuclear generation.

In addition, the industry has responded well to the security climate since 9/11. The nuclear industry operates some of the most secure, if not the most secure, sites anywhere in the country. In fact, most other industries could learn something from what you folks have been doing.

I want to thank the Commission and the Commission staff for the work they have done. They have turned then NRC into both an effective and efficient agency. I do appreciate their efforts, and we will continue to work with them to ensure that these efforts and positive results continue.

But today, we are kind of facing a crossroads. The next few months and years will determine whether or not nuclear energy will thrive in the 21st century. Nuclear power has a good story to tell: it is safe, low-cost, environmentally friendly, and, at 20 percent, an important part of our fuel mix. In fact, there is no reason why we don't, in the longrun, look at nuclear power, and there can't be a greater influence.

I have said this so often, Mr. Chairman, we have a crisis a lot of people don't want to admit is there. We have an energy crisis in this country, and I look at nuclear energy as a very important part of the solution of this problem that we have; fossil fuels, oil, gas, coal, nuclear, renewable and all of the above.

But I think as far as the potential that is out there, nuclear is it. I really believe, Mr. Chairman, that we can continue the progress that we have made and we can ensure that we are going to be able to resolve this crisis that we are faced in the nuclear energy, and its expansion will be a very important part of it.

I would ask unanimous consent to put the remainder of my statement in the record and look forward to the questions and the progress that you have made.

[The prepared statement of Senator Inhofe follows:]

STATEMENT OF HON. JAMES M. INHOFE, U.S. SENATOR FROM THE STATE OF OKAHOMA

Good morning and welcome to our witnesses today. I first want to thank Chairman Voinovich for holding this oversight hearing and for his continued commitment to oversight of the NRC. I believe we are at a cross roads for nuclear energy, but before I discuss where we are today, I just want to review briefly where we were in 1997 when I became Chairman of this Subcommittee.

- We hadn't had an NRC oversight hearing in over a decade,
- The relicensing process was estimated to take over 5 years per unit, if it could be completed at all,
- The NRC was more concerned about paperwork violations than real risk issues, and
- No one was even considering building new nuclear units.

Today, we have regular NRC oversight, the relicensing process is being completed on time, the NRC has moved to a risk-based climate, and people are actually talking about new nuclear generation.

In addition, the industry has responded well to the security climate since 9/11. The nuclear industry operates some of the most secure, if not *the most secure,* sites anywhere in the country. In fact, most other industries could learn something from the nuclear facilities.

I want thank the Commission, and the Commission staff, for the work they have done. They have turned the NRC into both an effective and efficient agency. I do appreciate their efforts and will continue to work with them to ensure that these efforts and positive results continue.

But today we face a cross roads. The next few months and years will determine whether or not nuclear energy will thrive in the 21st century. Nuclear power has a good story to tell. It is safe, low-cost, environmentally friendly, and at 20 percent, an important part of our fuel mix. In fact, there is no reason why in the long term, nuclear power can't or shouldn't increase its percent usage.

But there is work to do to ensure that there is the regulatory climate for new generation, enhanced security, and the long-term resources in order for the NRC to carry out its mission of ensuring the safety and security of our commercial nuclear fleet. We on this committee have an obligation to continue our oversight in order to help keep NRC on track and to understand what they need in order to carry out their mission.

This Congress, Senator Voinovich and I have introduced 3 bills to address many of the needs of the NRC: an NRC Fees bill; a nuclear security bill; and a bill to reathorized Price-Anderson. It is my hope that we can move all three of these bill shortly after Memorial Day recess.

This year marks the expiration of the NRC Fees law. In 2000, I authored that bill that brought fairness to the fees that NRC collects from its licensees, while providing that 90 percent of the NRC budget is paid for by those fees. That bill also ensured that NRC could not seek reimbursement for those items, such as their international programs, which don't provide direct benefit to those who pay the fees. Absent Congressional action reauthorizing the fees law, the NRC fee base would drop to almost 30 percent of its budgets leaving it in a terrible financial position.

This time Senator Voinovich and I are including in the Fees bill additional language to help with the human capital crisis at the NRC and a number of regulatory reforms such as eliminating the NRC antitrust reviews and streamlining the hearing process. Senator Voinovich has been a leader in addressing the human capital needs of the Federal Government, and NRC is an agency that headed toward crisis if we do not act. Much of the reforms in this bill were included in our 2000 legislation that passed both the Committee and full Senate by Unanimous Consent, but unfortunately were not included in what was signed into law.

We have also introduced a nuclear security bill. I want to thank Senator Voinovich for holding a classified hearing last week on this topic. This committee has twice reported out security bills, but they have unfortunately fallen victim to the fate of the Energy bills that they were attached to. It is my hope that we can once again pass a security bill and keep it separate from the energy bill and get it signed into law in the near future. Much of what we have included in past security bills has been implemented administratively by the NRC—and I applaud them

for those actions. But it is well past time that we provide them the additional authorities that can only be realized through legislation. The bill that I have introduced reflects those additional needs and I hope that we can get strong bipartisan agreement on moving those provisions very soon. NRC has done a tremendous job since the attacks of 9/11 and there is very little doubt that, because of the deterrent that these robust security measures provide, these facilities are not attractive targets for any terrorist who hopes to carry out a successful attack.

And finally, Senator Voinovich and I have introduced legislation to reauthorize Price-Anderson. Without this bill, and the certainty that it provides, the long-term future of nuclear power would be in jeopardy.

Because of oversight hearings like this one, we can talk about successes. Thank you for making sure that NRC is a priority to the Congress and I look forward from hearing from our witnesses today.

Senator VOINOVICH. Thank you.

Mr. Diaz, at last May's oversight hearing we discussed GAO's Davis-Besse report, which I requested. One of GAO's criticisms was that several of the issues that led NRC to not prevent Davis-Besse were identified in past GAO reports, the Commission lessons learned task force recommendations, and the inspector general reports. The GAO stated in their report that the NRC was reviewing "the effectiveness of its response to past NRC lessons learned task force reports." This is of great concern to me because I want to make sure that the Davis-Besse recommendations are fully and comprehensively implemented.

In a follow-up question at that hearing, I asked the Commission about the status of the report. This is the response: "The task force recommendations to conduct a more detailed effectiveness review of the actions taken, response to past learned lessons has been completed. The results of the review are being considered by the NRC senior management and the Commission to identify and take corrective actions as necessary."

However, it is my understanding that NRC is yet to complete the evaluation of this review or take an appropriate corrective action. Although I know you have taken them at Davis-Besse, which is more than 2½ years since the completion of the task force report and more than a year since our last hearing when it was discussed. Can you tell me when are we going to have a report on lessons learned and, as a result of lessons learned, what things the Commission is doing differently that are going to make a difference?

Mr. DIAZ. Yes, sir. Reality is that we are very well on our way to finishing every one of the recommendations of the task force that actually go to fix the problems that contributed to the Davis-Besse issue. We have presently 44 of the 49 issues have been completed. Four more will be completed in the next 2 or 3 months, and one issue, which is a lone, lead issue, which deals with modification

Senator VOINOVICH. Chairman Diaz, I am appreciative of that. The real issue here is we have had past reports and we have had a GAO review again, and we have all these lessons that we should have learned. As a result of all the past things that have gone on, all of the recommendations, we need to know specifically what the Commission is doing differently as a result of those reports that are applicable not only to Davis-Besse, but throughout the whole system, the 102 or 103 facilities that we have.

Mr. DIAZ. Yes, sir. What we have done is once we realized that we have not used all the things we knew during the Davis-Besse process, the Commission tasked the staff to come up with a process

that will ensure that the knowledge that existed in the agency, and specifically all those issues that have relationship to safety that were learned, will continue to be applied. We have knowledge management transfer that is taking place in the agency

Senator VOINOVICH. OK, all I can say is I want the report. OK? This is it. We learned this; here is what we are doing differently; here is how it is applied, so that we know that in fact the lessons learned are being applied. Because prior to Davis-Besse there were lots of recommendations from task forces about what to do, and the fact of the matter is that those recommendations weren't being followed by the Commission and, as a result of that, we had Davis-Besse.

Mr. DIAZ. We will get you the report and we will get you the results of the implementations of those actions.

Senator VOINOVICH. I would be grateful.

Last week, the NRC terminated its oversight panel, which is a sign, again, of the significant progress that has been made, and I congratulate you for that. You have been on them like hot sauce, and I commend the NRC, the operator and its employees for their hard work. At the same time that has occurred, the Perry Nuclear Plant in Ohio has received increased oversight. Can you please describe the recent developments at that plant and what the NRC is doing in response to that?

These are my two nuclear plants, and I am real interested in them, and I would like to know.

Mr. DIAZ. Yes, sir. We have been trying to see if we can relocate them, but we have not been able to do that. The reality is that Perry Nuclear Power Plant started having a series of problems in 2 areas that are of great interest to our safety programs: One is the human factors area and how people actually conduct their work, how they follow procedures; and in the corrective action program.

This program is where you actually put things that you need to have fixed, need to be corrected, they need to be properly dispositioned. The staff, during their normal inspections, and then in the inspections that actually lead to what we finished yesterday, which was our AARM, where we actually do the annual review of the plants, the Perry plant stands out as not being where it should be. We immediately notified them.

Tonight, there is going to be a public meeting at the plant site or outside the plant to discuss this finding. We are putting them on an increased oversight, and it will remain there until they take care of these issues that have been identified.

Senator VOINOVICH. Thank you.

Senator Carper.

Mr. MCGAFFIGAN. Mr. Chairman, could I just add one thing?

Senator VOINOVICH. Certainly, Commissioner McGaffigan.

Mr. MCGAFFIGAN. Perry has been very high on our screen for a couple of years now. It got into column 4 of the action matrix, which is the bad column—not the worst, but one you don't want to be, the one that gets you close attention—sometime last spring or summer.

We put in a plug for our monthly report to you, sir, that we have been trying to keep you up to date not just on Davis-Besse, but on

Perry. We give very aggressive attention to plants that are in trouble or give signs that they are going to be getting into trouble. We don't have very good leading indicators, I don't want to imply that—we had a discussion yesterday—but we have some leading indicators that seem to be leading, and we follow the plants.

Perry has, unfortunately, gotten very close attention from us, and even at Beaver Valley, which is Region I, not far from your State, in Pennsylvania, we had to return a license renewal application a couple of months ago. So we continue to give First Energy, as a whole, very close attention. Those are the three plants that they run, and they deserve our attention and they get our attention.

Senator VOINOVICH. Thank you.

Senator Carper.

Senator CARPER. Thanks, Mr. Chairman.

Gentlemen, what do we need to be doing in this committee and in the Senate and the Congress to enable you, to empower you to be as vigilant as you need to be to ensure the safety of nuclear power plants across the country? Give us a short to-do list and a time line, as well, for those tasks.

Mr. DIAZ. Sir, I appreciate the question and the support. I believe that in the area of legislation the committee and both Senator Inhofe and Senator Voinovich and yourself have already put on the table the type of actions that we need to both ensure the additional security that we need at power plants, including giving the right guns to the guards, being able to fingerprint the people when we need it. So all of those provisions and the human capital provisions are in there.

So we appreciate that support. We hope that this year we will see those things taking place, because they will help us a long way in making sure that we can respond in the security arena.

In the area of safety, which is our paramount focus, and in the area of new power plants, we find ourselves in the uncomfortable position of not having the resources to respond to what we believe are the new demands. We really have a very disciplined process in the budget. When we look at what we thought we were needing, we were acting, if I may use the word, in a fiscally responsible manner and tried to put in the budget just those things that we thought were absolutely indispensable.

At the present time we have a shortfall in the area of security. The House Appropriations Committee looked at our shortfall and added $21 million to our 2006 appropriation. We believe that we also will have a shortfall in the area of the new reactor licensing. We need to hire new people. We need to have the space. We need to be able to really prepare our inspection infrastructure. It is a totally different way of what we are doing now, which is really operational-based.

The support of the committee and the subcommittee in these areas will allow us to do our job.

Senator CARPER. What do we need to be doing with respect to Yucca Mountain to allow us to go forward and to prepare for a safe depository for nuclear waste for the near term?

Mr. DIAZ. Well, sir, we continue to observe——

Senator CARPER. When I say we, not just us in the Senate, but within the Administration as well.

Mr. DIAZ. Yes, I know. There is the fact that we are waiting for EPA and DOE to come up to us with a solution to a new standard. As you know, the 10,000-year standard was essentially considered not acceptable by the courts. EPA and DOE have responsibility to come with a standard that then we can proceed and put our rule into it. We are ready to do that; we have the manpower, we have the structure.

We continue to be ready to do whatever is needed for making a potential application of Yucca Mountain an effective process. Our adjudication system is ready; we have a licensing support network, which is probably the largest support network that has ever been assembled in this country with information technology, being able to address the issue. But in our case right now, we are in a holding pattern. We are actually looking at what they are doing, and we are ready to come in as soon as there is a resolution to this issue and go to work.

Senator CARPER. One other question. I would appreciate hearing from Mr. Jaczko as well. Let me just ask one other related question. Other countries—I think among them France and Japan—have acted to reduce the volume of nuclear wastes that are either created or produced at their reactors. What are the pros and cons of doing that? And are there any encouraging new technologies on the horizon that we might want to emulate?

That is for Mr. Jaczko and whoever would like to respond.

Mr. JACZKO. Well, I think if you are referring to the issue of reprocessing, that is certainly a very complicated policy decision. I think this is something that involves the entire Administration, and there are issues related to national security, our non-proliferation goals, that are intimately related to how we deal with decisions about reprocessing.

So certainly as a Commission there are issues that would come before us, if there were licensing actions, things of that nature, we would certainly be prepared to deal with those in the future, but at this time these are, in many ways, decisions that are for other policy organizations to make, and we then would potentially have regulatory activities related to those.

Senator CARPER. Do you want to add anything to that, Mr. Chairman?

Mr. DIAZ. Well, I do believe that what you said was totally correct, Senator. Reprocessing offers the capability of reducing the amount of long-lived radionucleides that would have to be stored. It is a complicated matter, like Commissioner Jaczko says, because of the issues of proliferation, if you really take those into account.

But the thing that complicates it in the United States is the economics of it. Fundamentally, at the present time, with the price that uranium ore has been having for years, there was no economic incentive to reprocessing the spent fuel pool. As uranium has become more expensive, then maybe it is not a bad idea to technically analyze the possibilities with reprocessing, as well as trying to resolve in the Congress and the Administration the issues that are attached to the security of the materials and to actually the benefits that will come with it regarding disposition of the waste.

Senator CARPER. Mr. Chairman and to my colleagues, I will just share with you that Senator Coburn and I serve as chairman and ranking member of another subcommittee, this one on Government Affairs and Homeland Security, whose responsibilities include nuclear proliferation, and the thought that comes to me here is the idea of perhaps a joint hearing with this Subcommittee and that subcommittee to look, maybe later this year, at the issue of reprocessing once again, and to hear about its timeliness and the appropriateness of us revising that.

Mr. MCGAFFIGAN. Sir, could I add one response? President Reagan, in October of 1981, ended any prohibition on reprocessing that had been initiated by Presidents Ford and Carter. It has been economics primarily, and non-proliferation, that have precluded reprocessing.

The old Purex reprocessing process that is used in the United Kingdom and France, and the Japanese have spent tens of billions of dollars getting ready to reprocess, is very, very expensive, and President Reagan was only willing to—the subsidy in his October 1981 memo was he was willing to consider Federal purchase of plutonium for the then-planned Clinch River breeder reactor as the only incentive that he was willing to have as a fiscal conservative to enhance reprocessing. So the existing reprocessing technologies I think our industry, over a 24-year period, has made a decision that isn't economical.

Our role would be to hold the hearing. The reprocessing plant would be subject to a prior hearing, whichever private sector entity came forward. In the late 1970s, that hearing was probably the most—prior to Three Mile Island—the most resource-intensive activity that the Commission was engaged in. Then it stopped.

Senator VOINOVICH. Thank you.

Senator Inhofe.

Senator INHOFE. Thank you, Mr. Chairman.

Chairman Diaz, last year—or maybe longer than a year ago—I asked a question about the potential increase in efficiencies and resource allocation, if you were to consolidate the 4 regional offices into the headquarters, in addition to the employees at the NRC headquarters and the resident inspectors, we have the 4 regions, which have been in place since the 1970s—which is a totally different environment than we have now.

I asked the question, would the NRC function more efficiently if we consolidated all the staff to the headquarters, keeping the resident inspectors in place? I think that would be important.

Now, in answering that question, what I don't want in an answer is, yes, we are looking at that and we are considering that, and this might be something worthwhile in the future. I would like to ask what have been the results of the review so far. What is the answer, are you going to do it?

Mr. DIAZ. Yes, sir.

Senator INHOFE. OK, that answers that question. Very good.

Mr. DIAZ. No, no, no, no, no. I just said yes, sir, I am going to answer.

Senator INHOFE. So the answer is no.

Mr. DIAZ. Yes. I have to be careful how I say yes, sir.

We have been considering this issue. The last time we looked at it, what we did is we consolidated into Region II in Atlanta all of the functions related to the fuel cycle facilities. So we actually went and did a certain amount of consolidation to resolve some of these problems that different regions have, different type of technical personnel. We further made a distinct effort in consolidating the materials issues.

We have actually provided an additional consolidation of materials issues in Region III. We asked the staff what else can be done, and the very, very thorough analysis came and said that at this time there is no significant advantage in consolidating the regions into headquarters or further consolidation.

Senator INHOFE. The staff that you asked that question, who gave you that answer, is that the staff in the headquarters here or is that the staff in the regionals?

Mr. DIAZ. No, we asked the question from the staff in headquarters. They do consult with the staff in the regions. There is obviously interest in the regions—and I realize that it is true—for them to maintain the operations, because they are close to the licensees; many of them are a couple of hours, 3 hours away from where the power plants are, they are where the manufacturers of radioactive sources are.

Senator INHOFE. So you have looked at this and now the staff has made this recommendation that it would not be a good idea. Do you agree with that recommendation?

Mr. DIAZ. I agree with the recommendation at the present time. I do believe that there are changes that are taking place in the way we do business, changes that are taking place in the way that information technology is allowing us to do the work and inspection and so forth, and I do believe that this is a question that the Commission will have to reconsider

Senator INHOFE. OK, that is fine.

Commissioner Jaczko, you are the new guy on the block, so you don't come already carrying the baggage of the past. You have looked at this with fresh insight. I would like to know what you think about this.

Mr. JACZKO. Well, I think——

Senator INHOFE. Business as usual or do you want to try something new?

Mr. JACZKO. I have had an opportunity, since I have been on the Commission, to actually visit 3 of our regional offices, and I found that—well, I think there are 2 examples. One, through my visits there, I found that the regions play a very unique role for the agency.

As the Chairman mentioned, they are in very close proximity to the licensees, so they are able to visit the facilities on a much more regular basis, in a way that is cost-efficient for the agency. That proximity and that access is extremely important as we pursue our safety mission.

Senator INHOFE. So you agree with the Chairman from your fresh outlook?

Mr. JACZKO. Absolutely.

Senator INHOFE. OK, that is fine.

Mr. McGAFFIGAN. Sir, could I mention that it is unanimous? We did send a report to Congress, I believe last year, and I would say, in light of housing prices in this area, it looked cost-prohibitive for any benefit that we might get.

Senator INHOFE. OK, that is fine.

Mr. McGAFFIGAN. In light of housing prices today, it would be even more cost-prohibitive, and we would lose a lot of good people.

Senator INHOFE. That is good.

Mr. Chairman, my time is about to expire, but I want to ask one more question and just get some responses here.

I am sure you have read the GAO's testimony in which they raise a number of issues. Would you like to respond to any of those specific questions that they raised?

Mr. DIAZ. Well, sir, we worked very seriously with the GAO when they were making this report. We take very seriously their recommendations. We do have disagreements with them, and some of the recommendations, for example, in today's statement or testimony, are a little bit outdated. However, some of them are very good recommendations, and we have actually acted on those ones that we consider have significant merit.

Senator INHOFE. OK, then just for the record, then, I would like for the 3 of you and for the Commission to respond to these things. Some of them may be outdated, some may not, but there are a lot of them out there. None of these comments are made in a critical vein, because I like what you are doing. A few years ago we started working together, and we have seen, in licensing and permitting, just a lot more efficiencies than we had in the past, so I think you are doing a great job.

Thank you.

But for the record, I would like to have those responses.

Mr. DIAZ. We will.

Senator INHOFE. Thank you, Mr. Chairman.

Senator VOINOVICH. Thank you.

Senator Jeffords.

Senator JEFFORDS. The Government Accounting Office released a report that I requested, along with a Vermont delegation and Congressman Oliver of Massachusetts, on tracking of spent fuel stored at the nuclear power plant. They will testify about it here today. You wrote to me last week that you were looking at the report's recommendations. One recommendation in this report is that the NRC must develop specific requirements for the control and accounting of loose spent fuel rods and segments.

Would you support action to require changes to the guidance that licensees receive regarding the records that they keep with respect to spent fuel?

Mr. DIAZ. Sir, we have already taken serious actions in that direction. The fact is that the finding of the missing spent fuel pieces in Vermont Yankee were initiated by the new inspection processes that the NRC has in place. However, we do consider a facile material control and accountability, whether it is fresh fuel or whether it is fuel that has already irradiated, a very serious issue. So we will consider very seriously whether we need to take any additional actions to enhance our processes to make sure that we have the

best material accountability program that has to be in there to be responsive to what we have seen in the licenses.

Senator JEFFORDS. Also, the GAO report suggests that inspection procedures for spent fuel need to be updated. In part, current inspection guidance developed in response to the Millstone incident led to the discovery of spent fuel missing at Vermont Yankee. Do you believe that the NRC has sufficient information about the problems with material control and accounting to proceed with revising the inspection system?

Mr. DIAZ. I believe we do. I believe that our revised inspection procedures give us a higher level of oversight. I do believe that we have communicated to our licensees the necessity that they have to maintain control and accountability of their materials. However, sir, the proof is in the pudding; we are continuing to look at a series of licensees that we believe might not be where they should be, and if they are not, then we will take appropriate actions. We will continue to exercise strict oversight over this area.

Senator JEFFORDS. I am pleased to hear that. The NRC's public document system, the ADAMS computer database system, is an important public information tool. It is the primary way that facilities, State regulators, and the general public, even this committee and its staff, have access to the NRC's documents. Frankly, lately it seems that it is not working as often as it is working.

Mr. DIAZ. I must admit that we all have had a little bit of a problem with ADAMS, but ADAMS is getting better. It is now becoming a Web site-based system. The bottom line was to make it more usable, more user-friendly, more powerful, more capable to be used. I believe we are getting there, and our staff has been very clearly given the task to ensure that ADAMS becomes what it should be, a premier tool to communicate with the public and with the Congress and all the stakeholders. I have been told, to look at it, that before this year ends we will have a fully equipped Web-based system capable of doing what ADAMS should be able to do.

Senator JEFFORDS. I believe you have answered this, but do you believe that the Commission has sufficient authority and resources to ensure that ADAMS is working properly over the long run?

Mr. DIAZ. We do.

Mr. JACZKO. Senator, if I could add.

Senator JEFFORDS. Yes.

Mr. JACZKO. One of the challenges that we are facing with ADAMS right now is that, as an agency, we have strived very hard to be very open and very accessible, and I think in many ways the NRC has been a real leader in that role. One of the challenges that we face and one of the reasons, sometimes, for some of these problems with ADAMS recently has been part of our process to review documents on the ADAMS system, to make sure that there aren't any documents that would provide information that could be used by terrorists or by other people whose intention is to do harm.

So that is one of the challenges that we have been faced with and one of the things that has led to some of the problems right now with ADAMS. So that is something we are working through and working to get that process completed.

Senator JEFFORDS. I am not sure if you answered this or not, but on April 6, 2005, the National Research Council, part of the Na-

tional Academy of Sciences, released a report on the safety and security of the commercial spent fuel storage. It has been reported that the Commission disagreed with some of the NAS recommendations and technical recommendations. I want to ask some specific questions regarding this report, its recommendations, and the Commission's follow-up.

The National Academy recommended earlier movement of spent fuel into dry cask storage to reduce the potential consequences of a terrorist attack. The NRC has disagreed with this recommendation. Would you comment?

Mr. DIAZ. Yes, Senator. We find that with the upgrades that have been done to both safety and security in nuclear power plants since 9/11, that storage of fuel in spent fuel pools is adequate, that there is really no additional risk to public health and safety from when these plants were designed or when they were evaluated. There is a slight advantage on putting the fuel in dry cask, but the cost of doing it, plus the significant risks that are associated with moving the fuel to dry cask do not justify to the Commission to undertake this movement.

We do believe that we have been responsive to several key recommendations from the National Academy, including the fact that spent fuel can be put in better positions in the pool or that additional cooling strategies should be put in place, and we agree with those and we are pursuing those very, very rapidly. But with regard to movement to dry cask, we believe that it definitely is something that can be done, but it is not justifiable in terms of the safety of the spent fuel pools.

Mr. MCGAFFIGAN. Mr. Chairman, if I could just add very briefly I am not sure that the Academy recommended. I am pretty sure that the Academy got mad at us at one point for saying that they had recommended early movement of the spent fuel. They recommended we look at it, but they were not recommending a specific course of action.

They specifically said that this was pretty tough stuff, it is very hard to do the cost-benefit analysis, it is very hard to make even qualitative judgments about benefits, but it wasn't a recommendation for early movement from spent fuels to dry cask storage, it was a much more nuanced Academy recommendation.

The other thing, the chairman did submit a report to Congress, in classified and unclassified form, in March that outlined our specific judgments about these things. We have not been passive. Last July we issued an advisory. In February of this year we had a conference with all licensees who have spent fuel pools, a secure conference, and then we issued an additional set of instructions on February 25th, with responses due by May 31st.

There are lots of other things we could tell you about in this area that we are doing. We got the report last July. So we have been acting on it since last July.

Senator JEFFORDS. I am pleased to hear that. Thank you.

Senator VOINOVICH. Thank you.

We are going to have another short round of questions for you.

It is my understanding that the House provided an additional $21 million to the NRC. It is also my understanding that that is not adequate, that in addition to that $21 million, the Commission

wants another $20 million to get the job done. I am very concerned about that because my original understanding was that the $21 million was going to take care of it. So I think that we need to get back from you a real good documentation about what it is that you would do with this additional money and how relevant it is to your being able to move forward with some of the things that you have to do and we are asking you to do.

Mr. DIAZ. Well, we would be pleased to do that, sir. They are 2 totally different things. The House was concerned with how do we actually close out this issue in security, especially the so-called plan specific assessments for spent fuel pools, series of issues regarding materials protection. So we put together a package that responded to the concerns of the House.

At the same time, the Senate was concerned, and we testified in a meeting with Senator Domenici and Bingaman on the issue of what do you need to really get the structure for new plant licenses, and that is where the other $20 million happens to come from.

So they are two different pieces, and I am sorry for the confusion if we did not make that clear. But they are actually 2 totally separate issues, and we would be pleased to——

Senator VOINOVICH. I would like a breakdown of it. Is the $21 million too much for security? Could some of that money be reduced so it would go for something else? This is pretty important.

The other quick question is when we had the closed session you talked about your training facility in Tennessee, and I would like to see some cost benefit analysis. They send everybody down to Tennessee to get trained. How much does that cost? If that were moved to Washington, how much money would be saved?

I am also asking, and I am sure my committee members share this—when I was governor, I talked about harder and smarter, and more with less. At the same time you submit your information to us, I would like to know what steps, if any, you have taken to try and figure out how you can save money at the Commission. That is going to be very important in terms of my consideration of urging the additional money that you are asking for. I want to be satisfied about that.

Mr. DIAZ. Sir, we will be pleased to send you an additional report that clearly marks out the steps the Commission has taken to be as fiscally conservative as we can be, but at the same time being able to discharge our functions. I think your staff received, this week, a series of answers on these issues, but we are going to review it and make sure they are thorough, complete, and resubmit them to you.

Senator VOINOVICH. Thank you.

Mr. MCGAFFIGAN. Sir, could I add one thing just to give you perspective on this matter? We talked a little bit last week about it. We face 4 major challenges in the years ahead. One is security; and that doesn't seem to be going away, and we have a lot of rulemakings to do, we have a lot of national source tracking system to put in place, etc.

The second is this generational change. We talked about the need to hire 800, 900 people—I think it was documented in the letters we sent you—over the next 3 years. That is, a quarter of our staff will be 3 years or less with the agency. So there is just a bow wave

of generational change occurring, which drives our infrastructure. We need to rent out the space and all that. We have Yucca Mountain and we have advanced reactors.

The first 2 of those things are absolutely going to happen, the security and the generational change, and we have to manage it. We face great uncertainty with regard to how many applications we are going to get for advanced reactors. We, as the chairman said, underestimated in last year's budget. The industry has been playing its cards close to the table until recently. Then Yucca Mountain, I can't predict when DOE will file an application, but it will be the largest administrative proceeding in the history of mankind when it does happen.

So we have those 4 challenges. I didn't even mention Chairman Inhofe's favorite, which is license renewal. We are going to continue to have license renewal applications. We are going to continue to have enrichment plant applications. We are going to continue to have mock plant applications from DOE. Those are not in my top 4. Those are very important to many members, but the top 4 are enormously resource-intensive, and we try to frugally use the resources the Congress gives us.

Senator VOINOVICH. Senator Carper.

Senator CARPER. Thanks, Mr. Chairman. I have 1 question and a request. Let me just make the request first. I have a note here that Senator Clinton regrets not being able to attend the hearing, and she asks if we would simply tell the panel she regrets her absence and looks forward to working on security legislation that we have talked about here earlier today.

My last question, if I could, is a question regarding Senator Voinovich's bill that I have co-sponsored to reauthorize the NRC's ability to collect fees from licenses. In the bill there is language that proposes to limit the scope of environmental review under NEPA, and specifically it requires that only the facility to be licensed be evaluated, and eliminates the requirement to include any consideration of the need for or, in the alternative, to the proposed facility.

This may have been touched on earlier, but I want to come back to it again. NRC has completed license extensions, I think, at about a dozen plants, and has several applications that are pending. I presume you have done NEPA reviews at those facilities. Let me just ask again. How many alternatives are you considering now and have you been forced to look at non-nuclear alternatives in these cases? Finally, is this a significant area of concern as the NRC prepares to review these new license applications?

Mr. DIAZ. I really do not understand the question. You went from no nuclear alternatives to nuclear alternatives. Are you talking about sites?

Senator CARPER. I think what I am going to do is, I am going to submit this question in writing, and we will ask for you to just respond to it, if you will.

Mr. DIAZ. I would be pleased to do that.

Senator CARPER. Thanks so much.

That is it, Mr. Chairman.

Senator VOINOVICH. Thank you.

Senator Jeffords.

Senator JEFFORDS. No further questions.

Senator VOINOVICH. Senator Obama.

Senator JEFFORDS. I am sorry?

Senator VOINOVICH. I was just going to say, do you have any other questions?

Senator JEFFORDS. No.

Senator VOINOVICH. OK.

Senator Obama, welcome. We are glad that you are here.

Senator OBAMA. Thank you very much, Mr. Chairman. I appreciate it.

You know, I had the opportunity to be in the closed hearing and addressed some of the most pressing questions that I had, so I don't know how broad the scope of this session is. I would just want to reiterate my general view that, given the ongoing energy demands that we have, we are, I think, out of necessity going to be taking a look at the possibility of nuclear power plant expansion.

There seems to be a number of areas of concern. One is a mechanism to standardize design, something that I think I addressed last time. My understanding at least was that we are trying to move in that direction, which presumably would not only help us secure sites, but would also reduce some of the potential regulatory lag involved in approving facilities. The second aspect was fuel storage. I know you have addressed that a little bit before I arrived.

Can we just talk about your staffing levels and whether, if in fact we started to see a willingness on the part of the industry to try to start building more plants, whether you guys currently have sufficient staffing levels and budget levels to keep up, or whether you anticipate a need to increase your budget to do what needs to be done?

Mr. DIAZ. Thank you, Senator, for the question. These are the kind of questions we really like, because fundamentally the answer is no, we do not have the staffing levels that could be needed if we receive the number of applications for design certification, for early site permits, and for combined construction and operating licenses that are now sounding around which we are getting letters and expressions of interest.

In this regard, we have come up with a plan that we believe is adequate to allow us to maintain our safety oversight over the operating fleet, which we cannot slack off. We need to maintain the level of activities that are ongoing. We need to maintain the levels of activities over licensing activities.

We disposition about 1800 licensing activities every year. Every single one of them is important. Some of them are considered more important than others. For example, Senator Inhofe has at the top of his list license renewal and power upgrade, and for very good reasons. They are all important activities.

To be able to actually conduct the high technical work and prepare for all of the interactions that will be taken, including potential adjudications on these issues, we have come up with a new staffing program that increases about 145 technical persons in this coming year

Senator OBAMA. What percentage increase would that represent?

Mr. DIAZ. Well, if you look at what we call the NRR licensing staff, that is approximately, I would say, about 10 percent increase from where we are.

Senator OBAMA. Would there be a sort of commensurate increase in your budget, then, about a 10 percent increase, or slightly more?

Mr. DIAZ. Actually, for that it would be just about $20 million, and that licensing activities is a little bit over $200 million. So it is approximately that.

Senator OBAMA. Is that sort of phased in over a certain period of time?

Mr. DIAZ. No, this is on top. This is in addition of what we already have programmed. Then, the following year, year 2007, there would be a $25 million increase to where we have programmed to be able to keep putting the right infrastructure, both personnel, space, work stations, training, protractors. A lot of those things need to be in place by the time we actually receive these applications.

Mr. MCGAFFIGAN. Senator Obama, as I said in response to Senator Carper, we are facing the need to net hire 300 or 400 people, and we lose about 5 percent of our 3,200 person work force each year to retirement and whatever, so that is an extra 150 per year. So you are talking about 800 people the first 3 years.

If the full nuclear renaissance occurs, I just want to put you on notice in 2010—this is the leading edge. If we have multiple applications at multiple sites, our agency is going to have to grow additional hundreds of people while we are also losing 150, 160, 180 people a year because we have a bow wave of retirements. It is a very difficult thing to manage; not just for us, it is hard for the industry. They are facing the same generational change that we are facing.

So this is coming along at a time, the potential nuclear renaissance, that we are dealing with security; we are potentially dealing with Yucca Mountain, which is the largest administrative proceeding, in my view, in the history of mankind, 40 million pages of documents in discovery; and managing the generational change.

This is the leading edge. I don't want to be in front of Senator Voinovich 4 years from now, or you, Senator Obama, and you say, where are all these hundreds of additional people? It all is dependent on decisions made by the private sector that are uncertain decisions. We want to be able to meet the need without wasting resources.

Senator OBAMA. Right. So I guess what I am trying to figure out is what the ramp up schedule on something like this is, given that, to some degree, it is contingent on what private industry does. If you suddenly got 10 applications for new plants next year or over the next 2 or 3 years, are you able to hire quickly enough to accommodate that?

Mr. DIAZ. No, sir.

Senator OBAMA. You cannot.

Mr. DIAZ. No, sir. This is why we keep telling the industry that they need to give us early warning. The number of people with the skills are just not there, nor are they trained into our work processes and the way of doing things. So we need to have some heads-

up. So the earlier the notice, the better the service that we can do this Nation.

Senator OBAMA. Is this all premised on sort of a static model of how staffing takes place? Have you evaluated whether we are getting the most bang for the buck right now; whether we are sufficiently productive in terms of how staff operates, updating lines of authority and organizational structures and changes that may be made in terms of design, so forth?

Mr. DIAZ. It is a very dynamic model, but it has some fundamental assumptions. We started with 3 fundamental assumptions that we could only do like 3 major licensing decisions a year, and that was fundamentally, and that was what was worked out with OMB. OMB says this is a level that you can work with, so we went at that level.

Once we are at that level, we actually are able to put a dynamic structure into place where people that were working and doing design certification actually can then move to the other arena. So there is a plan, and staff has been working very hard not only at that plan, but how to train the people to be able to do the different jobs.

Senator VOINOVICH. Senator Obama, you know, one of the things that I think that we ought to do—because this is a big deal in terms of this thing—I am going to suggest that this committee have a hearing just on the budget and what the future looks like, and ask you to brief our staffs first and come back and talk about the future, and what are some of the conditions and so on, and your projections and what you need and so on, because this is going to have a lot of relevance on how hard we encourage members of Energy and Water to come up with some more money so that you can do your job. The better informed we are, the more relevant and more attention they will pay to our recommendations.

Senator OBAMA. I am open to that, Mr. Chairman, and happy to yield back.

Mr. MCGAFFIGAN. Sir, could I mention one successful model? That is license renewal. And I hope the industry is going to follow it with new reactors. We had 2 plants come in, Calvert Cliffs and Aconi, as sort of trials of our system, and our system succeeded. We are much more efficient today, as we process, I believe, 10 different additional applications. We have re-licensed 32 plants; we have another 16 or 18 that are currently in the process; and we have become more efficient.

But what we did was we issued guidance as to how to do it, the staff followed it with the first couple applicants, then we issued a generic aging and lessons learned report that made it easier—standardized applications, standardized our process—and it has worked very, very efficiently.

I would predict that a future Commission will try to follow the license renewal model. I think the industry wants us to follow the license renewal model. I think we are likely to get a limited number of applications early on. Those are going to be resource intensive. We will not resource-load 5 years after that at the same rate that the first 2 are, because the history of license renewal has been that we are much more efficient today.

So long as we and the industry are on the same page, there are lots of guidance documents that haven't been written yet and are best informed by an actual application. So we have a successful model.

I know when Chairman Diaz and I sat in front of this committee in 1998 for the first of the oversight hearings, there was great, great skepticism that we were going to be able to deal with the bow wave of license renewal applications that were on the horizon. I think it is a success that the bipartisan commission has handled those applications. It is very hard; it is reading tea leaves to sort of figure out what our needs are. We will be more efficient, but if there are 12 applications, it is going to take more than 2.

Mr. DIAZ. Mr. Chairman, we welcome the opportunity to come and put this thing in a manner that the committee can see the options and the decisions. We will be ready.

Senator VOINOVICH. The first thing we are going to do is get the staff involved immediately so that when we do have a meeting, it is as productive as it can be.

Thank you very much.

Senator Isakson is here, and before we go to the next panel, Senator, would you like to——

Senator ISAKSON. First of all, I want to apologize to the panelists and you, Mr. Chairman, for being late.

Second of all, I want to thank Chairman Diaz and Chairman Voinovich for the secured briefing about 10 days ago, which was extremely informative. For the record, my impression of your attention, sir, and the other Commissioners to the security of present and future nuclear facilities is absolute, and I appreciate your attention to that and your commitment to that.

I really have one question, since I probably would be redundant in anything else that I ask. You have how many current applications for new licenses?

Mr. DIAZ. We have no current applications for new licenses. We have 3 applications for early site permits in which the site is going to be analyzed from the environmental viewpoint, so we actually do an environmental impact statement. Those 3 early site permits are presently on track and they are also presently being adjudicated.

Senator ISAKSON.With satisfactory environmental analysis, they would move to the second step?

Mr. DIAZ. That is the expectation, that with the satisfactory environmental impact and the site being cleared, that gives them 1 of the 3 legs of this process. The second leg is a design that has been certified by the NRC. We have several designs that have been certified, but the industry is now working to get 2 new designs certified, which are what we call Generation 3 Plus, they are beyond the advanced generation, they have additional features, and the industry is very interested in these 2 designs. We also have a French design. The EPR has already expressed a strong interest in being certified in the United States. So that is the second leg.

If you have a site permit and you can pull off the shelf a certified design, you have now two-thirds of what you want. Then an applicant can come and say now I want to apply for a combined construction and operating license. That is the last step. That is a

major licensing activity; it is actually the one that we consider we have an applicant for a plant.

We have no applicants for COL presently, but what we have been discussing is what we hear from the industry is that we could have three, four, or five in the 2007, 2008, 2009 period. So what the Commission is trying to do is make sure that we will be responsive to the needs of the Nation at that time, when those things come in.

Senator ISAKSON. So the three legs of that stool are site, design and final COL, is that correct?

Mr. DIAZ. That is correct.

Senator ISAKSON. I know it may vary because of things that come out, but what is a reasonable time from the first leg of the stool to the last leg of the stool?

Mr. DIAZ. They can go in parallel, they don't have to be one after the other. The early site permits are going on, the design certifications are also going on.

Senator ISAKSON. At the same time. OK.

Mr. DIAZ. At the same time. So they can go in parallel. They can reference each other or not. So there are all sorts of combinations that can take place. The most economical and streamlined combination is somebody comes and says I want to apply for a COL and I am going to use this site that I already have and I am going to use this certified design.

By the way, that also costs a lot less money. From our viewpoint, it is about half the process, because you already have two-thirds of your three legs. They can also do a combination of those things, and, as you know, utilities have the capability of being selective; they may want to do certain types of things.

There is no doubt that an existing site has an advantage over other sites, because I believe the community is already familiar with the technology, with the benefits, with the way the plants operate. They already have infrastructure with both water, railroads, electrical grid, so there are a series of advantages. And I would be surprised if the first few applicants would not be using an already existing site which has a site permit, and they will pick off the shelf a certified design.

Senator ISAKSON. Thank you very much, Mr. Chairman.

Thank you, Mr. Chairman.

Senator VOINOVICH. Thank you.

I would like to thank the members of the Commission for being here today. We will continue to work with you to try and make your life easier.

Mr. DIAZ. Thank you.

Senator VOINOVICH. Our next panel is Mr. Jim Wells, who is the Director of Natural Resources and the Environment at GAO; Marilyn Kray, who is president of NuStart Energy Development; and Dr. Edwin Lyman, who is the Senior Staff Scientist for the Global Security Program at the Union of Concerned Scientists.

Before we get started, I want to remind the witnesses that their entire statements will be submitted into the record, and I would urge them, to the best of their ability, to limit their presentations to 5 minutes.

Mr. Wells, if you are ready, we will start with you.

STATEMENT OF JIM WELLS, DIRECTOR, NATURAL RESOURCES AND THE ENVIRONMENT, GOVERNMENT ACCOUNTABILITY OFFICE

Mr. WELLS. Yes, sir, I am ready.

GAO is pleased to be here to discuss NRC. As I listened to the NRC commissioners earlier, they clearly have a right to be proud about what they have accomplished, and optimistic about what they are achieving. But I think we at GAO also have a right to suggest that they do it faster, and I will talk about that and some of our recommendations.

Clearly, the world for NRC has changed since 9/11, and the future of nuclear power depends heavily on how well NRC does its job. While the safety and security record has been good, things have and will happen that will challenge NRC's credibility for guaranteeing the safety of the Nation's aging fleet of plants.

Over the past 2 years, we have had the fortunate opportunity to issue 15 reports on NRC operations. While our reports have focused on identifying ways to strengthen NRC's activities, I think it is fair to say that we have documented very positive steps that have been taken by the agency. One example is the substantial effort that NRC has made in working with the industry to enhance security. They still have a way to go, however.

Another example is NRC's considerable effort to analyze what went wrong with Davis-Besse and to incorporate lessons learned. Again, we think they could perhaps do some things faster.

I want to just briefly summarize what we think NRC still needs to do and highlight for you some challenges that we think NRC is going to face in the future if it is truly going to be a credible regulator of the industry.

In summary, of all the reports, I will just quickly say that we found that NRC has not developed adequate security measures for sealed sources of radioactive materials, the stuff they use in medicine, industry, and research which could be used to make a dirty bomb. We found that the oversight of physical security at the plants could be strengthened. We found that NRC's analysis of plant owners' contribution of funds for decommissioning may not be completely accurate.

We found that issues surrounding the shutdown of Davis–Besse revealed important weaknesses in the NRC oversight of its safety. We found that controlling and accounting for the location of spent fuel needs to improve. The chairman of the NRC commented this morning that true these issues are in the past; the past 2003, 2004. We would prefer to be here not next year or the year after raising the same type issues.

Turning a minute to the future in terms of what we think NRC faces as challenges, if you want to keep and enhance the credibility as a regulator for our commercial nuclear power plants, in response to the agency's limited resources and the desire to reduce the regulatory burden and cost on the plants, as we see it, NRC is trying to accomplish two major things, and these are presenting some challenges. On the one hand, NRC is trying to implement a risk informed regulatory strategy that targets the industry's most important safety-related activities. We would agree with that because

it gives them an opportunity to prioritize their limited resources in terms of what they can pay attention to.

On the other hand, they are trying to strike a balance between verifying what the plant's compliance with its own inspection by having the NRC look at what the plant is doing; they are trying to balance that level of activity. At the same time they are trying to afford the licensees the opportunity to demonstrate on their own that they are operating the plants safely and they are policing their own activities. So that is the balancing act that NRC faces in the future.

Accomplishing these tasks will not be easy. We believe that NRC must develop the ability to identify emerging technical issues and they need to adjust a little faster than what they have done in the past in terms of regulatory requirements before safety problems develop. We believe that NRC clearly faces challenges in balancing this oversight and the industry compliance so that it can identify diminishing performance in the industry at individual plants before they become a problem.

I use as an example Davis-Besse. Clearly, that plant stayed in a green condition right up until the event. Yet, the problem that occurred, that cause had been developing for many years.

Finally, as the chairman of the committee talked about today, NRC is facing challenges regarding managing of its resources while meeting the increasing regulatory and oversight demands. There is no doubt that the existing resources have been stretched at the NRC to enhance security. Its pressure on its resources is going to continue as the Nation's fleet of plants age—these nuclear power plants are getting older—and the industry's interest in expansion grows.

Are we going to build new plants? Are we going to license new plants? Are we going to re-license? And are we going to increase the power output from the existing ones? All this is going to take time and effort by the NRC.

In closing, I just want to recognize and say that GAO, in the activities we performed, we appreciate the complexities of the NRC in terms of what they need to do to be a good regulator and to continue strong oversight efforts. Clearly, NRC is doing a lot of things right, but we are here today, and have been as we continue to provide oversight, that it still has important things and important work that they need to do.

Whether NRC, in the future, carries out this regulatory and oversight responsibilities in an effective and creditable manner will clearly have a significant impact on the future and the direction of whether or not we have an increased use of nuclear power.

If I have one minute left, I want to respond, Mr. Chairman and Senator Carper, you asked the question what does NRC need.

Senator VOINOVICH. Could we save that maybe for the questions, because you have gone over your time.

Mr. WELLS. I would be glad to stop here and wait and answer any questions you might have.

Senator VOINOVICH. That would be great if you could do that. That would be swell. Thank you.

Senator VOINOVICH. Ms. Kray.

STATEMENT OF MARILYN C. KRAY, PRESIDENT, NUSTART ENERGY DEVELOPMENT

Ms. KRAY. Good morning, Chairman Voinovich, Senator Carper, and members of the subcommittee. My name is Marilyn Kray. I am the vice president of Exelon Nuclear. But I am here today in my role as President of NuStart Energy Development.

The NuStart consortium is comprised of nine power companies and two reactor vendors. The power companies are Constellation, Duke, Entergy, EDF North America, Exelon, Florida Power & Light, Progress Energy, Southern Company, and TVA. The reactor vendors are Westinghouse and General Electric.

As individual companies, we recognize the importance of nuclear power to our country's environment, electricity reliability, and the energy independence. We further recognize that there are certain challenges facing a new nuclear investment. If left alone, these challenges would inhibit the viability of the nuclear option for the future.

My testimony identifies seven preconditions to the construction of new power plants in the United States. These are: The demonstrated need for base load power; confidence in the long-term solution to the spent fuel storage issue; regulatory process certainty; completed advanced designs; re-establishment of the nuclear infrastructure; public confidence in nuclear power; and, lastly, acceptable financial returns.

We noted that there were two challenges in the list above that were not being addressed by ongoing initiatives, yet required prompt attention. These were the need for regulatory certainty and the need for completed advanced designs. Given the nature of these challenges, in that they were both generic as well as one-time, we decided that the best strategy was for the industry to address them as a unified effort. Accordingly, the NuStart consortium was formed.

The consortium power companies adopted or endorsed the two technologies, the Westinghouse AP–1000 and the General Electric Economic Simplified Boiling Water Reactor. Last spring, NuStart submitted a proposal to the Department of Energy. Our plan is to work with the rector vendors to complete the design engineering necessary to deploy these technologies. Additionally, we plan to submit two Combined Operating License, COL, applications, to the NRC, one for each technology. Our current plan is to submit these to the NRC in early 2008 with the NRC to review to be concluding in the 2010–2011 timeframe.

I had the opportunity last year to appear before this subcommittee, and since then significant progress has been made. Highlights include the following: The NuStart proposal has been accepted by the Department of Energy and a cooperative agreement is in place; legal documents, governance, structure, and project management controls have been established to ensure that the NuStart entity will function efficiently; Westinghouse received its final design approval for the AP–1000 from the NRC, which is a milestone in the design certification process. It expects to receive final design certification in December of this year. General Electric has been engaged in meaningful discussions with the NRC staff as

part of their pre-application phase of design certification. They expect to submit their application to the NRC this summer.

NuStart most recently selected six finalist sites from a population of over 40, and these will be the subject of our COL applications. The finalist sites are Bellefonte in Alabama, Calvert Cliffs in Maryland, Grand Gulf in Mississippi, Nine Mile in New York, River Bend in Louisiana, and Savannah River in South Carolina. The next step is for NuStart to further analyze these six sites and select one to be the subject for each of the two applications.

By meeting the objectives as outlined in our agreement with the DOE, we believe that we will be taking meaningful steps in not only assuring that the nuclear option is available, but also in obtaining additional confidence around certain vital investment assumptions. The alternative to the NuStart approach is to do nothing and hope for the best. We see this as synonymous with phasing out the nuclear industry in the U.S.

I recognize that NuStart was not the only one busy, and that the Senate staff has been working on legislation resulting in three pieces that are before the committee. We find these three pieces of legislation to be important in setting the stage for new plants, and we urge the committee to approve them. The provisions as outlined in the Price-Anderson, the fees restructuring of the nuclear safety and security are all very important to the growth of nuclear power.

I thank you for your interest and the opportunity to appear before you this morning.

Senator OBAMA. Mr. Chairman, I just want to suggest for Ms. Kray that she not use the phrase nuclear option during her testimony.

Ms. KRAY. Well taken.

Senator VOINOVICH. Thank you.

Dr. Lyman.

STATEMENT OF DR. EDWIN LYMAN, SENIOR STAFF SCIENTIST, GLOBAL SECURITY PROGRAM, UNION OF CONCERNED SCIENTISTS

Dr. LYMAN. Mr. Chairman and members of the subcommittee, on behalf of the Union of Concerned Scientists, I appreciate the opportunity to present some of our views today on the security and safety of nuclear power plants in the United States. I think I will deviate slightly from my written remarks to address some of the things we have already heard this morning.

First, I would like to thank the Chairman for raising the issue of the Perry plant and its increasingly degraded safety performance. Obviously, the issue of safety culture was one of the lessons that should have been learned at Davis-Besse, and it appears from the fact that even under increased oversight of First Energy's performance, the Perry plant's own attention to detail and performance and procedures, according to strict guidelines, is deteriorating indicates that maybe First Energy has not learned the lessons of Davis-Besse, and this of great concern.

Another issue of concern to me with regard to the safety of the Perry plant is that it is one of the 13 nuclear power plants in this country that suffer from a containment design flaw that the NRC has known about for a long time but is dragging its feet in actually

addressing, and this is the fact that Perry and the other 12 plants in this category have containment structures that are significantly weaker and smaller than most of the nuclear power plants in this country.

The NRC has known for a long time that if a station blackout occurs at one of these plants, that is, if both offsite power and onsite power is lost, the potential for a hydrogen explosion could lead to failure of a containment like Perry's with near certainty. This could be addressed quite simply by adding additional backup power capacity so that, in the event of a station blackout, there will be a way to power the hydrogen ignitors, which would burn off hydrogen safely before a detonation could occur. The solution to this is not expensive, and the NRC actually decided, through its risk inform process, that such additions were warranted.

However, more than 5 years after starting to address this issue, nothing has happened, and I am concerned about the potential at Perry and other plants. I would urge the committee to look at this issue, because it is an example of how the NRC appears to be more interested in relaxing regulatory burden than strengthening it when warranted.

We also have great concerns about the security of nuclear power plants and nuclear materials in NRC-regulated facilities. I am testifying today in an unusual position in that I have been part of a hearing at NRC involving the security of plutonium-bearing MOX fuel at a nuclear power plant in South Carolina, and I have had access to safeguards information, both site-specific and relating to general NRC security policies. I can't discuss any of that information today, unfortunately, but I can say that the information I have seen does not make me feel any better about the state of security at nuclear power plants.

Senator Jeffords has raised the issue of the material control and accounting of spent fuel at Vermont Yankee. We are also concerned about material control and accounting and security of materials that could be used to actually make nuclear explosive devised, as opposed to dirty bombs. The NRC does regulate the security of several facilities in this country that have enough material onsite that, if stolen, could be used to make a nuclear weapon. These include poorly protected university research reactors, which have highly enriched uranium, and now the Catawba plant in South Carolina, which became a Category I plutonium facility by virtue of receiving 80 kilograms of weapons-grade plutonium in the form of MOX fuel at that plant.

The NRC should be increasing its attention to strengthening the security that terrorist groups like Al Qaeda would not be able to steal this material to make a nuclear weapon. The NRC also has a responsibility to show the rest of the world how to protect nuclear materials like plutonium. In fact, it is supposed to be working with Russian regulators to strengthen their security on these types of materials, but the NRC is actually backtracking by weakening standards in some cases on securing plutonium from theft, and this is something of considerable concern to us.

We are also greatly concerned about the sabotage threat to nuclear reactors. Just to state what the stakes are, if a terrorist group was able to gain forced access to a nuclear power plant, I am con-

vinced that within a matter of minutes they could start the process to cause a meltdown of the fuel and a significant radiological release to the environment.

The NRC itself has been evasive about what the consequences of that type of event would be, so I undertook the opportunity to do that analysis myself, using NRC's own consequence assessment computer codes, and the result of that was a report that is focused on the Indian Point nuclear power plant.

Just to discuss some of those results, I found that a terrorist attack in the worst case I looked at could cause up to 44,000 deaths from acute radiation sickness; 5,000 deaths in the long term from cancer; and economic damages that would exceed $2 trillion. These are the stakes and these are why security must be strengthened at nuclear power plants.

Just to review some of the problems that I continue to see with security at power plants, one is the design basis threat level. When it was set in 2003, the standard was not what is the threat faced by nuclear power plants today by our adversaries, it was what is the greatest threat that we should expect utilities to be able to protect against themselves. Those threats may not be the same and, in fact, they aren't the same, because when that threat was reviewed by other Federal agencies, most of them recommended additional capabilities be added to the design basis threat. However, NRC apparently did not adopt those recommendations. The threat must be reviewed by other agencies, intelligence agencies, and their recommendations must be taken seriously.

Another important aspect is force-on-force tests. Force-on-force tests are an important component of security because the best security plan on paper may have problems that will not be revealed until they are actually tested. There are significant weaknesses with the force-on-force testing program which I have outlined in my testimony, and I recommend that you read those.

Guard fatigue is another issue.

Senator VOINOVICH. Dr. Lyman, could you kind of wrap it up?

Dr. LYMAN. Security guards have a hard job, and they really need enough rest to be able to perform that job. NRC has taken steps to control the work hours of security guards, but we understand those rules are being violated, are not strictly adhered to in some cases. That is a serious issue.

In our view, legislation is needed to address the design basis threat issues, force-on-force, and the others I have mentioned.

Thank you for your attention.

Senator VOINOVICH. Thank you very much.

Ms. Kray, you have expressed support for the human capital provisions in S. 858, the Nuclear Fees Reauthorization Act, which Chairman Inhofe and I have introduced. As your coalition looks to construct new nuclear power plants, I am wondering how much consideration is given to ensuring that the industry itself has the skill and knowledgeable work force it needs to get the job done.

Does this bill help at all the industry's human capital needs? And is the industry doing anything to address this issue? You were here for the testimony before.

Ms. KRAY. Right. Yes, I was.

Senator VOINOVICH. We have a real human capital challenge out there for the NRC to have the people that they need to get their job done. Then the question is do you have the people that you need to get the job done? You are both going to be drawing probably from the same pool, and what are we doing about expanding that pool? And does any of this stuff help you?

Ms. KRAY. The short answer is no, we don't have the human capital yet. The reason that we certainly endorse the legislation supporting the NRC resources is because we can empathize with that situation in that we are in the same one. We have very similar demographics with respect to an aging work force, and we also see a horizon of additional exciting, but, nevertheless, additional work for us.

We have, over the past year, perhaps been in somewhat of a dilemma: not wanting to get too far ahead of ourselves, but at the same time wanting to be able to plan appropriately. We have begun discussions with a number of the architect and engineering firms—Stone & Webster; Sargent, Lundy and Shaw—who would provide the personnel to actually construct the crafts and the trades that would be constructing these plants, looking at what the time lag would be to get a qualified work force up and running.

The good news is that considering the lag time associated with building a new plant, we do think that we can plan for that. Essentially, the thought is, on the work side, the craft and trades, if you want to build it, they will come.

The other issue is looking into the universities. We have seen increased enrollment in the nuclear area, in part, we believe, based on feedback from the universities, that is the optimism and perhaps renaissance of the industry that is attracting more professionals. We are also comforted a bit by a resurgence, particularly groups such as the North American Young Generation of Nuclear Engineers, which has become very active.

So, again, in short, the answer today, we do not have that. It is a challenge for us going forward, and we are optimistic that we can meet it.

Senator VOINOVICH. And you agree that, in terms of manpower, they really have a challenge not only for what you are suggesting—and if you heard the testimony, they need some more help from you, but given some is this for real, are you going forward, and so forth, so that they can plan for that?

Ms. KRAY. That is right. In December of 2004, NuStart submitted a letter to the NRC indicating our plans for submittal of the two COL applications. We do recognize the ramp-up time that they have in responding to these, and, again, we share the NRC concern for their staffing their own agency as far as us having to staff our own next generation.

Senator VOINOVICH. We are appreciative also that the industry wants to continue the percentages in terms of the cost. I wonder would you like to comment, if you feel like you are qualified to comment, about the information that we had the House pass $21 billion more and the Commission said today they need another $20 million? How do you look at those numbers?

Ms. KRAY. I am probably not the best qualified to respond to that. Mr. Marfurtel of NEI, I know, had provided some testimony

for the record addressing some of the bills, and that is based on the collective industry perspective. Anything beyond that, I would be happy to submit as follow-up for you.

Senator VOINOVICH. I wish, Dr. Lyman, you had been able to be in that closed session, because some of the issues you raised were brought up at that session.

Ms. Kray, do you feel confident that the Commission is doing everything possible to transfer knowledge about current safety and security environment to the new facilities? In other words, we have learned some lessons about security. We have increased security efforts underway. Some day I would like to really measure all of the additional costs that we have incurred because of a guy named Osama bin Laden and 9/11. It is just incredible what is happening.

But the question I have is because of those increased security concerns, do you believe that in the designs of these that you are going to incorporate the best information that we have available today in terms of security?

Ms. KRAY. The power companies are working with the two reactor vendors, General Electric and Westinghouse, to ensure certainly that the enhanced security guidelines that have come out post–September 11th are incorporated into their designs.

What is still remaining out there is if there are going to be any future changes to design basis threat or any additional requirements that might be imposed on new plants. The reason that I say that is because now is the time, when the designs are still on the drawing board, that it is easiest to incorporate any further changes. So if there are any additional changes beyond those known, the earlier we have those available, then the easier they can be incorporated into the evolving designs.

Senator VOINOVICH. Senator Carper.

Senator CARPER. Ms. Kray, I am going to come to you second for a question, but I want you to be thinking about the question, then I am going to ask Mr. Wells to respond to my first question. I would like for you to revisit the issue I raised with the NRC commissioners, and that was the issue of disposal of nuclear waste.

Going forward, if we are going to see a renaissance of nuclear energy and the next generation of power plants be built, how can we reduce the amount of waste to dispose of? How can we do that safely? If you would be thinking about that, I would appreciate it.

Mr. Wells, I said in my opening statement that a great deal of responsibility rests with the NRC and on their need to be vigilant. Last year, in testimony, I think, before the House Government Reform Committee, the GAO highlighted a number of concerns with NRC's oversight of security measures. I don't know how familiar you are with that, but, specifically, GAO said a number of things. I just want to read briefly a couple of those.

GAO stated at the time that, "NRC is not yet in a position to provide an independent determination that each plant has taken reasonable and appropriate steps to protect against the new design basis threat." GAO went on to say, "NRC's review of each facility's new security plans, which are not available to the general public for security reasons, has primarily been a paper review; it is not detailed enough for NRC to determine if the plans would protect the facility against the threat presented in the design basis threat."

GAO went on to say, "In addition, NRC officials are generally not visiting the facilities to obtain site-specific information and assess the security plans in terms of each facility's layout. NRC is largely relying on force-on-force exercises it conducts to test the plants, but these exercises will not be conducted at all three facilities for 3 years."

In conclusion, GAO said, "NRC's oversight of plant securities could also be improved. NRC is not following up to verify that all violations of security requirements have been corrected or taking steps to make lessons learned from inspections available to other NRC regional offices and nuclear power plants." That is the end of the quote.

Mr. Wells, what I would simply like to do today is to ask if you would like to let us know if you believe that these concerns, stated about a year ago, have been addressed, are being addressed. And if not, do you have any recommendations for us to ensure that they are addressed?

Mr. WELLS. Yes, sir. I can say with fairly high confidence that those were the words that I said at that testimony; they sounded accurate. That was the status that we were finding at the NRC at the time we did that audit. We still stand by those findings. We are in the process of doing a much more comprehensive assessment of where the NRC is today related to those very significant findings.

We are looking at the postulated threat that is out there. We are looking at the design based threat that has been established by the NRC and comparing that, as well as an objective we are visiting individual plants, looking at the actual brick and mortar that is being put in place to defend against that design basis threat. We hope to have that report available at the end of this year. We assume it will be in both the public and a classified version.

I can say that, as we are doing our work, we are very vigilant in watching the force-on-force type program that NRC is putting in place. They are conducting these at a pace of approximately two a month. It is true that until you actually test what has been put in place, you do not have that answer with great certainty as to whether they can be protected. They are 3 years away from getting that type of answer. We are looking at the actual program and techniques that they are using.

They have some growing pains; I will admit that. They are evolving and changing their inspection and their process as they go and as they learn ways in which they can be.

So, yes, NRC is proceeding to have a better confidence 3 years from now that they can make a much more confident public statement than they could in October of 2004, when we looked at that process.

Senator CARPER. Thank you. Thanks very much.

Ms. Kray, can we return to your earlier question? Again, we are going to have a new generation of nuclear power; the issue of waste, what to do with it. Feel free to comment on Yucca Mountain, but any other new technology that other countries may be using, that may be under development. I welcome your thoughts.

Ms. KRAY. Sure. I stated in the testimony understanding the long-term solution for spent fuel storage is a precondition for going

forward and actually investing, that is, signing a purchase order. But, at the same time, we don't want to stand still on the other challenges while this one is being addressed. And the industry fully endorses the science behind Yucca Mountain. Yet, at the same time, we are facing the reality of the political challenges associated with it. That then suggests, at least today, two possible alternatives.

The first one, with respect to Yucca Mountain, is to look at it as more of a monitoring and retrievable facility, as opposed to just the long-term storage. That is, you would exchange the burden of having additional commitments with respect to retrieval and monitoring in exchange for relieving some of the uncertainty as far as trying to analyze well out into years that might be beyond the capability of computer modeling. It is expected that that would certainly help the DOE in their analysis, and then the NRC in their review of it.

In addition to the Yucca Mountain piece is revisiting and reprocessing. Essentially, the United States has not been active in this area, so reprocessing as it stands today, from a utility perspective, is not attractive from a cost perspective. But we also know that perhaps if given the appropriate attention, the reprocessing could satisfy both certainly the safety proliferation concerns, and then also the cost-effectiveness. So reopening or re-examining the possibility of reprocessing would certainly be warranted.

Senator CARPER. All right, thanks very much. Our thanks to each of you for being with us today and for your testimony. Thank you.

Senator VOINOVICH. Senator Isakson.

Senator ISAKSON. Thank you, Mr. Chairman.

Mr. Wells, you were talking about force-on-force evaluation. I read Dr. Lyman's printed testimony with regard to some questions he raised. How does GAO monitor that process, onsite or by reading reports?

Mr. WELLS. I am sorry?

Senator ISAKSON. Do you monitor by physically observing one of the force-on-force tests?

Mr. WELLS. Absolutely. That is the value of GAO in terms of having resources available to do original audit work. We made a request and NRC accepted and invited us to attend a force-on-force that was conducted in New Jersey at a nuclear power plant, and we were observers. We participated in the exercise into the wee hours of the morning and watched the process; took a lot of notes about how things went.

Senator ISAKSON. I thought I heard you say—and I am asking if I heard wrong—that in your evaluation they had identified technique problems and improved them. I think something to that effect. So that process is improving on the force-on-force evaluation?

Mr. WELLS. Our observations are that NRC is working very diligent toward—we had pointed out previously a lot of faulty techniques in the force-on-force weaknesses that exist. They went through a pilot exercise program; they worked with NEI and they actually developed a new program that they have started within this 2005 year.

They are in that process. They have probably done about a dozen force-on-forces, and it is a process that is evolving and they continue making improvements. But our initial observation, until we finish, is greatly improved over the old process.

Senator ISAKSON. Ms. Kray, when you talk about siting needs, needs base is a tremendous part of your final siting decision. That is future needs more than existing needs, or is it existing needs?

Ms. KRAY. Are you referring, sir, to the need for power in the area?

Senator ISAKSON. Yes.

Ms. KRAY. It primarily is in the future, because we recognize that even if we were to start today to prepare an application, the earliest we would think that it would come online would be 2015. So we are looking at a longer horizon.

Senator ISAKSON. On that basis, let me put in a plug for the Savannah River site. Having seen it, known what it is used for in the past, and the Regulatory Commission's comments that previous uses are excellent sites, that is a good one. We have a growing need in the State of Georgia.

My only other question, Mr. Chairman, also in your nine items of concern that NuStart had—I think it was nine or seven——

Ms. KRAY. Seven, but that is OK.

Senator ISAKSON [continuing]. One of them was financial concerns. Now, I know how Georgia operates in terms of the Public Service Commission, and I was a part of the legislation when Plant Vogel was approved, financed, and everything. Are you talking about the capital financing to build the facility or are you talking about the rate-making process and how the future revenue comes in?

Ms. KRAY. Primarily the financing to build it. And that needs to be looked at depending upon whether a new facility will be in a regulated environment or deregulated environment, because that certainly imposes different conditions on the investor. But essentially, we see that incentives will be needed to address the additional investment hurdles that will be facing just the first wave of the new nuclear plants, and we need to review any that are considered in context certainly of incentives offered to other fuel alternatives as well.

As utilities, we are not predisposed to any form of generation, and that is, if convinced, that we need to build something, we will build whatever is certainly in compliance with all regulations and standards, but also one that has the best benefit for our shareholders. And we see with nuclear, at least for the uncertainties associated with that, are facing some challenges that are unique to that, especially compared to the other base-load alternatives.

Senator ISAKSON. Well, real quickly—because I know my time is running out—in the 1970s, construction while in progress type financing mechanisms, CWIP, were the desire obviously, but one of the big problems that happened was the tremendous overruns that took place in the construction for these facilities. My question is will CWIP still be the ideal mechanism for a company for financing construction? And if it were, do you feel now that construction of nuclear plants, the problems that we had in the 1970s with the

cost overruns, and the tremendous overruns in some cases, is highly less likely because of the technology and the past experience?

Ms. KRAY. We are optimistic that there have been lessons learned from that. I mean, there is not a good track record in the United States for having built plants on time and on budget. We can look to some success in the Asian markets, and we are also comforted by the fact that the plants we are adopting now are somewhat more simpler, that is, less components to actually build and construct.

There have also been advances in modular construction which we would intend to use. So we would expect certainly a more commitment and sense of urgency around the construction, and also a more ease because of the design.

With respect to the financing structure, we are open to some more innovative approaches, and that is looking for the vendors to engage with us in turnkey type of financing, and, again, models that we have seen similar to the Finland reactor that was recently commissioned. So we would be looking to that, and certainly one of the concerns is the financing during construction, the impact on the dilution of earnings. That remains a hurdle for the investment of a large capital- intense project.

Senator ISAKSON. Thank you.

Senator VOINOVICH. Senator Jeffords.

Senator JEFFORDS. Mr. Wells, based upon your study, does GAO believe that the NRC has sufficient information about the problems with material control and accounting to proceed with revising the inspection system?

Mr. WELLS. Yes. We agree that there is a problem between us and NRC. We disagree at the speed at which they are implementing the corrective action. We suggested they already had enough. They are 5 years into this problem. They suggested to us that they weren't quite ready yet, they wanted to continue to study it.

Senator JEFFORDS. What could Congress do to improve the materials tracking at power plants?

Mr. WELLS. Excuse me?

Senator JEFFORDS. What could we do, as Congress, to improve materials tracking at the power plants?

Mr. WELLS. You have a regulatory agency that has a regulatory requirement that the licensee knows exactly where all this material is. The difficulty we encountered in terms of figuring out what caused this material to be missing was the lack of specificity in those recommendations.

I believe you need to hold NRC accountable to write that specificity in there so that every licensee knows what type of inventory they need to use, how it is to be inspected, and how it is to be recorded, especially as it relates to missing and spent fuel pieces that are currently not addressed in the regulation. NRC agrees with that, yet they continue to want to look further to see if it is more prevalent elsewhere.

Senator JEFFORDS. Thank you for that answer.

Thank you, Mr. Chairman.

Senator VOINOVICH. I would like to thank the witnesses for coming here this morning. If you have any comments that you would

like to make in writing to the committee, we would be more than happy to receive them. Thank you very much.

The meeting is adjourned.

[Whereupon, at 11:00 a.m., the subcommittee was adjourned.]

[Additional statements submitted for the record follow:]

STATEMENT OF HON. BARACK OBAMA, U.S. SENATOR FROM THE STATE OF ILLINOIS

Mr. Chairman, thank you for holding this hearing.

As electricity demand throughout the Nation increases in the coming decades, we will be challenged in how best to meet these consumption demands without sacrificing the environment. That means creating jobs, protecting water and air quality, establishing energy independence, and using all of our energy resources fully and wisely.

I strongly support greater energy conservation and greater Federal investment in renewable technologies such as wind and solar, which ought to receive greater attention in our national energy policy than they likely will this year.

However, as Congress considers policies to address air quality and the deleterious effects of carbon emissions on the global ecosystem, it is reasonable—and realistic—for nuclear power to remain on the table for consideration. Illinois has 11 nuclear power plants—the most of any State in the country—and nuclear power provides more than half of Illinois' electricity needs.

But keeping nuclear power on the table—and indeed planning for the construction of new plants—is only possible if the Nuclear Regulatory Commission is vigilant in its mission. We need better long-term strategies for storing and securing nuclear waste and for ensuring the safe operation of nuclear power plants. How we develop these strategies is a major priority for me.

I look forward to hearing the testimony of the witnesses, and I thank the Chair for holding this hearing.

STATEMENT OF NILS J. DIAZ, CHAIRMAN, U.S. NUCLEAR REGULATORY COMMISSION

INTRODUCTION

Mr. Chairman and members of the Subcommittee, it is a pleasure to appear before you today with my fellow Commissioners to discuss the U.S. Nuclear Regulatory Commission's programs. We appreciate the past support that we have received from the Subcommittee and the Committee as a whole, and we look forward to working with you in the future. I request that my written testimony, on behalf of the Commission, be submitted for the record.

The NRC is dedicated to the mission mandated by Congress—to ensure adequate protection of public health and safety, promote the common defense and security, and protect the environment—in the application of nuclear technology for civilian use. We have taken an integrated approach to safety, security, and emergency preparedness in carrying out this mission. Many of the Commission's initiatives over the past several years have focused on enhancing safety, security and emergency preparedness, while improving the effectiveness, efficiency, and openness of our regulatory system. I will highlight our key ongoing oversight and licensing activities, including pertinent initiatives.

REACTOR OVERSIGHT PROGRAMS

The Reactor Oversight Process has now been implemented for 5 years, with increasing effectiveness and maturity. We believe that this program is a significant improvement over the former inspection, enforcement, and assessment processes, and has brought a more disciplined and objective approach to oversight of nuclear power plants. Performance indicators and inspection findings for every power reactor can be found on NRC's public web site, as well as our current assessment of each reactor's overall performance. We continue to strive to make further enhancements to the program, and specifically to improve the predictability of performance degradation with Performance Indicators.

As you know, the NRC staff has devoted significant resources over the past 3 years to oversight of the Davis-Besse nuclear power plant in Ohio. We took these actions following the discovery of significant degradation of a portion of the reactor vessel head. The NRC authorized the plant to restart in March 2004 only after an extensive plant recovery program and comprehensive corrective actions by the licensee, and considerable NRC inspection and assessment. With the restart decision,

the NRC issued a Confirmatory Order requiring independent assessments and inspections at Davis-Besse to ensure that long-term corrective actions remain effective. Overall, the plant has been operating safely, and the NRC staff recently determined that plant performance warrants termination of the special panel that was created specifically for the oversight of Davis-Besse. However, the NRC is continuing increased regulatory oversight under the reactor oversight process, including continued oversight of the independent assessments required by the Confirmatory Order.

In April 2005, NRC proposed a $5.45 million fine against the licensee, FirstEnergy for violations of NRC requirements associated with the significant reactor vessel head damage discovered in March 2002 at Davis-Besse. This is the largest single fine ever proposed by the NRC. This substantial fine emphasizes the high safety significance of FirstEnergy's failure to comply with NRC requirements, and the company's willful failure to provide the NRC with complete and accurate information. Matters related to Davis-Bessie have also been referred to the Department of Justice.

As previously reported, we have undertaken a critical review of our programmatic and oversight activities to evaluate our own actions associated with the reactor vessel head degradation at Davis-Besse. This review includes NRC's internal Davis-Besse Lessons Learned Task Force Report together with reports from NRC's Office of Inspector General and the Government Accountability Office. Our corrective actions and program improvement efforts resulted in 49 significant recommendations. Currently, staff has completed addressing 44 of the 49 recommendations. Four of the remaining items will be completed within the next few months. The one remaining action, which requires development of an engineering code, has a long lead time.

NRC recognizes that communication failures were an underlying cause for issues discovered at Davis-Besse. The corrective actions outlined in the lessons-learned task force action plans specifically address communications. There has been a significant improvement in the communications among NRC regional, headquarters, and site offices, resulting in improved oversight activities.

In response to the Commission directive issued in August 2004, the NRC staff is currently developing a list of safety culture attributes, indicators, and objective measures and identifying gaps relative to the evaluation of safety culture. The staff's activities will take into account the ongoing industry initiatives and the experience of foreign regulators. In October 2004, a guidance document outlining NRC's expectations for establishing and maintaining a safety conscious work environment, a key attribute of safety culture, was published for comment. The staff expects to issue the final document this summer. The next step is to modify the Reactor Oversight Process to more fully address the management of safety and safety culture issues by licensees, and to develop better methods, tools, and training for the NRC's inspection staff.

REACTOR LICENSINQ PROGRAMS

The reactor licensing program, coupled with a strong oversight program, ensures that operating nuclear power plants maintain adequate protection of public health and safety throughout the plant's operating life. NRC licensing activities include using state-of-the-art science, engineering and risk assessment methods and information from operating experience to establish reactor safety standards, to promulgate the related rules, regulations, orders and generic communications as appropriate, and to review applications consistent with these requirements. In Fiscal Year (FY) 2004, NRC staff completed 1,741 licensing actions involving all 104 licensed reactors.

- *License Renewal*

One of the most significant types of licensing actions for existing reactors involves license renewals. These reviews are focused on plant aging issues, including a thorough determination of the plant's passive components. In 2004, seven reactors had their licenses renewed for an additional 20 years and two reactor licenses were renewed thus far in 2005. That brings the total number of renewed reactor licenses to thirty-two. In every instance, the staff has met its timeliness goals in carrying out the safety and environmental reviews required by our regulations. Sixteen additional license renewal applications are currently under review. The agency recently returned a license renewal application covering two reactors to a licensee because the staff's initial review determined that the application was not acceptable for docketing. The Agency also held significant discussions with another licensee about the adequacy of its license renewal application. We expect that almost all of the 104 reactors licensed to operate will apply for renewal of their licenses, and the staff will continue to face a significant workload in this area for the next 7 to 10 years.

• *Power Uprates*

Another significant type of licensing action, called a power uprate, involves a request to raise the maximum power level at which a plant may operate. Improvement of instrument accuracy and plant hardware modifications, in addition to improvements in computational tools and engineering models enabling more accurate engineering analyses, have allowed licensees to propose power uprates from the level initially authorized while maintaining appropriate safety margins. The focus of our review of these applications has been and will continue to be on safety.

To date, the NRC ias approved 105 power uprates which have safely added capacity equivalent to more than four large nuclear power plants. Currently, the NRC has 11 power uprate applications under review and expects to receive an additional 16 applications through calendar year 2006.

The NRC closely monitors operating experience at plants that have implemented power uprates. The NRC has observed cases of steam dryer cracking and flow-induced vibration damage affecting components and supports for the main steam and feedwater lines in Boiling Water Reactors with extended power uprates. We conducted inspections to identify the causes of several of these issues and evaluated many of the repairs performed by the licensees. We continue to closely monitor the industry's response to these issues. We have factored this experience into our review of pending applications and plan to do the same for future applications.

• *New Reactor Licensing*

Improved safety and reliability performance have resulted in significant overall improvements in nuclear power plants, including electrical generation output and production costs. The strong performance, increased electrical demand, and inclusion of nuclear energy in our nation's energy mix appear to be conducive to industry interest in new construction of nuclear power plants.

The NRC is prepared to discharge its responsibilities if applications for new power plants are filed. We anticipate that applicants for new nuclear power plants will utilize the licensing processes promulgated in 10 CFR Part 52, which was developed to provide a more stable, timely and predictable licensing process. This process is designed to resolve safety and environmental issues, including emergency preparedness and security, prior to the physical construction of a new nuclear power plant. Under 10 CFR Part 52, the design certification process resolves the fundamental technical and safety issues related to the plant design, while the early site permit process resolves safety and environmental issues related to a specific potential site. Use of the design certification and early site permit processes can significantly increase regulatory certainty because the issues resolved through these two processes can be referenced in an application for a combined construction permit and operating license. This is referred to as a combined license. This license would specify inspections, tests, and analyses which the licensee must perform, and the acceptance criteria that will be used to verify conformance with the regulations before the facility can commence operation. The NRC considers Part 52 to be a strong and viable approach for review of future reactor applications and is working to incorporate recent experience gained from design certification reviews, current early site permit reviews, discussions with nuclear industry representatives, and input from the public to further enhance this process.

The NRC has already certified three new reactor designs and codified them in the regulations, making them available for new plant orders. These designs include General Electric's Advanced Boiling Water Reactor and Westinghouse's AP600 and System 80+ designs. In addition, the NRC issued the Final Design Approval for the AP1000, and its proposed design certification rule was recently published for public comment. The NRC encourages early communication with potential applicants to identify unique design features or challenging licensing issues through the pre-application process. Currently, the NRC is engaged in conducting preliminary discussions on six additional reactor designs. These discussions indicate that we could receive several design certification applications in the near future.

The NRC received three early site permit applications in late 2003 for sites at which operating reactors already exist in Virginia, Illinois, and Mississippi. Schedules are in place to complete the safety reviews and environmental impact statements in approximately 2 years from the date of an application. In fact, the NRC staff has already issued draft safety evaluation reports and draft environmental impact statements on all three early site permit applications for public comment. The mandatory adjudicatory hearings associated with the early site permits are currently ongoing.

Finally, Part 52 provides for a combined construction/operating license process which allows applicants to seek, in a single application, a license authorizing both construction and operation prior to construction. This leads to combining adjudica-

tion of licensing issues in one hearing, instead of the two hearings utilized previously. Furthermore, the efficiency of NRC's safety-focused reviews would be substantially increased if applicants utilize an early site permit and certified design in their combined license applications. Although specific plans from the industry are not yet available, the NRC may receive up to five combined license applications beginning in 2007–2008.

The Commission is fully committed to ensuring that our agency is ready to meet the expected demand for new reactor licensing through maintaining a strong regulatory framework and adequate staffing and funds for handling multiple combined license applications. We will continue to work with stakeholders to address issues associated with implementation of our licensing process and Congress to ensure that our resource needs are identified.

SECURITY

The Commission continues to impose new requirements, when appropriate, to enhance security of nuclear facilities and materials and communicate these requirements to our licensees. Our efforts also include close communication and coordination with the Department of Homeland Security (DHS) and other agencies in the intelligence and law enforcement communities.

- *Nuclear Power Plant Security*

On February 25, 2002, the NRC required additional protective measures and strategies by each power plant licensee to protect against land-based and waterborne attacks and to provide additional mitigative capabilities for large explosions or fires at nuclear power plants, including those that could be caused by aircraft attack. Furthermore, increased coordination with local, state and national authorities was implemented to strengthen both prevention and mitigation. NRC power plant licensees were required to implement responsive measures by August 29, 2002. The NRC conducted inspections of each facility, required action to address noted deficiencies, and is in the process of further confirming implementation of best practices across the industry.

Additional Orders were issued from January 2003 through April 2003. This set of Orders addressed access control, physical barriers, training and qualification programs—as well as work-hour limits—or security personnel, capabilities to defend against more challenging threats, and spent fuel storage and transportation. For the requirements relating to the supplemental threat characteristics, additional site-specific analyses were required. NRC licensees implemented these orders by October 29, 2004. Licensee measures to address supplemental threat characteristics were evaluated immediately upon submission, and implementation continues to be inspected by a variety of means.

The NRC is currently developing a proposed rule and supporting guidance to codify supplemental requirements related to the Design Basis Threat (DBT). The proposed rule, due to the Commission in June 2005, is expected to be issued later this year for public comment, and the final rule is scheduled for completion in 2006. Also, we have redefined our baseline inspection program for physical protection and are phasing in the new inspection program consistent with the new requirements at power reactors. As a complement to licensee security measures, NRC is working with DHS and the Homeland Security Council, as well as other partners to enhance the integrated Federal, State, and local response planning for threats and attacks on nuclear facilities. We are also supporting DHS's comprehensive review of security and emergency preparedness of nuclear power plant sites under the National Infrastructure Protection Plan.

The NRC has completed a set of security assessments and identified mitigation strategies for NRC-licensed nuclear facilities. Thus far, the results of these assessments have validated the actions NRC has taken to enhance security as well as areas needing further improvements. These efforts have continued to affirm the robustness of these facilities, the effectiveness of redundant systems and defense-in-depth design principles, the value of existing programs for operator training in severe accident management strategies, and emergency preparedness. Assessments performed to date confirm the low likelihood of damaging the reactor core and releasing radioactivity that could affect public health and safety.

Further, these assessments confirm that even in the unlikely event of a radiological release due to terrorist activities, the NRC's emergency planning basis remains valid. These assessments also indicate that significant damage to a spent fuel pool is improbable, that it is highly unlikely that the impact on a dry spent fuel storage cask would cause a significant release of radioactivity, and that the impact of a large aircraft on a transportation cask would not likely result in a release of radioactive material. Thus, we believe that measures implemented with respect to

nuclear power plant safety, security, and emergency planning programs continue to provide reasonable assurance of adequate protection of the public health and safety. We are continuing to perform detailed plant-specific studies to further enhance our understanding of appropriate mitigative capabilities and to ensure effective implementation of these capabilities.

We continue to implement the force-on-force exercise inspection program to evaluate licensees' defensive capabilities and identify areas for improvement. In late 2004, NRC began full implementation of a triennial force-on-force exercise program for power reactors following a pilot force-on-force exercise program. The triennial force-on-force exercise program applied lessons learned from the pilot program and additional enhancements including the use of Multiple Integrated Laser Enhancement System (MILES) equipment, Composite Adversary Force (CAF) standards, improved controller training, and other enhancements to improve the realism of the exercises while maintaining safety of both the plant and personnel.

We have reviewed the Wackenhut Corporation's program for the CAF for force-on-force exercises, including the hiring and training of new members in accordance with the CAF standard established by the NRC. The review found that the Wackenhut Corporation's program meets the NRC's CAF standard, confirmed that appropriate management and administrative controls were in place within the Wackenhut organization to provide adequate independence between the CAF and nuclear guard force, and that some CAF members are selected from sites where security is provided by Wackenhut's competitors. Experience with recent force-onforce exercises has proven the existing CAF to be a significant improvement in ensuring a uniform high quality for mock-terrorist attack exercises.

In relation to the study conducted by the National Academy of Sciences (NAS), the U.S. Congress directed the NRC to take the necessary steps to improve the analyses related to spent nuclear fuel storage at commercial reactor sites, including the preparation of site-specific modals, and to ensure timely application of this information by the utilities to mitigate risks. The NRC has taken numerous actions to enhance the security-of spent nuclear fuel. The results of security assessments completed to date show that storage of spent fuel continues to be safe and secure. Nonetheless, the Commission agrees with the NAS recommendation that plant-specific analyses are needed and the NRC is conducting them and continuing to improve its analyses related to spent nuclear fuel.

- *Material Security*

Since September 11, 2001, the NRC has thoroughly re-evaluated its safeguards and security programs. To date, has issued over 16 different categories of Orders and Confirmatory Action Letters covering hundreds of licensees and actions involving radioactive materials of greatest concern. The NRC continues to devote considerable effort to determining what additional actions should be used to enhance the security of these materials in use, in storage, or in transport. The emphasis of this effort is on preventing the use of radioactive materials that have the potential to pose a risk to public health and safety if used in a radiological dispersal device or a radiological exposure device (RDD/RED).

The Commission, in coordination with our Department of Energy (DOE) colleagues, has taken the following actions to improve the security of radioactive sources of greatest concern: (1) issued advisories to licensees to enhance security measures; (2) issued the DOE/NRC Interagency Working Group Report on RDD/REDs, which defined threshold quantities for radioactive materials that are the highest risk and have a potential for malevolent use; (3) worked with the Departments of Energy and State and the international community to reach agreement on which radioactive materials and sources are of the greatest concern, consistent with the International Atomic Energy Agency (IAEA) Code of Conduct on the Safety and Security of Radioactive Sources; (4) approved a final rule amending its export and import regulations, in coordination with the Departments of State, Energy, and Homeland Security, to impose more stringent controls over the Category I and Category II materials defined by the IAEA Code of Conduct; (5) is developing a National Source Tracking System to track radioactive materials of greatest concern specified in the IAEA Code of Conduct on a permanent basis; and (6) developed an interim data base of Category I and II radioactive sources for both NRC and Agreement State licensees which will be maintained until the National Source Tracking System is complete.

EMERQENCY PREPAREDNESS AND RESPONSE

NRC recognizes the importance of the integration of safety, security, and emergency preparedness and response to fulfill the primary NRC mission of protecting public health and safety. Since September 11, 2001, the NRC has increased its focus

on potential terrorist scenarios as initiating events. As part of the Orders issued in February 2002, the NRC required nuclear power plant operators to make enhancements in several areas of emergency preparedness, including emergency response facilities, emergency response organizations, classification of and response to credible threats, and evaluation of a broader range of hazards. Nuclear industry groups and Federal, State, and local government agencies have taken an active role in the prompt implementation of these measures and have participated in drills and exercises to test new planning and response elements.

The NRC conducted a formal evaluation of the emergency preparedness planning basis in view of the current threat environment and determined that emergency preparedness at nuclear power plants remains strong. Improvements have been made in the areas of communications, resource management, emergency exercise programs, and NRC guidance documents used by licensees. These improvements are reviewed and inspected. Recently, the Commission directed the staff to issue a generic communication to licensees to further enhance emergency preparedness in the post 9/11 environment. The NRC intends to conduct outreach activities with external stakeholders, especially state and local government agencies, to describe the enhancements and solicit feedback on these changes and other emergency preparedness and response issues of mutual interest.

The NRC has also implemented the National Response Plan on schedule. Between October 2004 and January 2005, NRC staff briefed over 400 industry and government stakeholders in all four NRC regions on the implementation of the National Response Plan and the National Incident Management System.

MATERIALS PROGRAM

The NRC, in partnership with the 33 Agreement States, conducts comprehensive programs to ensure the safe use of radiological materials in a variety of medical, industrial and research settings. As some of NRC's responsibilities, including inspection and licensing actions, have been assumed by Agreement States, our success depends in part on their success, and we closely coordinate our activities with the States.

The NRC is developing a web-based materials licensing system that is expected to provide a secure method for licensees to request licensing actions and to view the status of licensing actions. In addition, the NRC, with assistance from other Federal agencies and the States, is establishing a National Source Tracking System that will be used to monitor radioactive sources that warrant the greatest control. The implementation of the National Source Tracking System continues to be a high-priority effort, and this project remains on schedule to be operational in 2007.

The Commission has also implemented a major rule change related to large fuel cycle facilities which requires licensees and applicants to perform an integrated safety analysis that applies risk-based insights to the regulation of their facilities. Major licensing reviews currently underway use the requirements of the new rule. These licensing reviews include two proposed commercial gas centrifuge uranium enrichment facilities.

The first of these proposed enrichment facilities would be located in New Mexico and the second in Ohio. Louisiana Energy Services submitted an application for its facility in Eunice, New Mexico, to the NRC in December 2003. USEC then submitted its application to the NRC for its site in Piketon, Ohio, in August 2004. The NRC staff expects to complete its review of the Louisiana Energy Services' application and issue both the Final Environmental Impact Statement and the Safety Evaluation Report next month. The NRC staff review of USEC's application is well underway, and the staff is working to meet the established thirty-month schedule.

In March 2005, NRC staff authorized construction of a mixed oxide (MOX) fuel fabrication facility at the Savannah River site in South Carolina as part of the DOE's program to dispose of excess weapons grade plutonium. At present, an adjudicatory proceeding concerning construction authorization for the facility is before the Commission's Atomic Safety and Licensing Board. The NRC staff is also providing support to its Russian counterparts regarding the licensing of a Russian MOX facility that will have a design similar to the U.S. facility.

In addition to the new facilities discussed above, the NRC regulates 7 fuel facilities in California, North Carolina, South Carolina, Tennessee, Virginia, and Washington. NRC's oversight of these facilities includes licensing actions, inspection, enforcement, and assessment of licensee performance.

NRC also authorized Duke Energy Corp. to use four MOX fuel assemblies, containing uranium and plutonium, as part of the nuclear fuel at its Catawba nuclear power plant in South Carolina. The MOX fuel assemblies designed for use in the Catawba reactor were produced by combining surplus plutonium from dismantled

U.S. nuclear weapons with uranium into a form that can be used by commercial nuclear power plants. This usage of the MOX fuel assemblies at Catawba is the first use of MOX fuel in a commercial power reactor as part of the ongoing U.S.-Russian plutonium disposition program being implemented by the DOE.

NUCLEAR WASTE PROGRAM

The NRC has made significant progress on activities related to protecting public health and safety in relation to disposal of nuclear waste. A major focus of these activities has been, and continues to be, ensuring that the agency is prepared to review a potential application by DOE to construct a deep, geologic, high-level radioactive waste repository at Yucca Mountain, Nevada. The Nuclear Waste Policy Act requires the NRC to complete its safety review of a license application, conduct a public hearing before an independent licensing board, and issue a decision on construction authorization in 3 years after submittal, with a possible extension to 4 years.

In July of 2004, the D.C. Circuit Court of Appeals vacated the 10,000-year compliance period established by the Environmental Protection Agency (EPA) and incorporated in NRC's regulations for Yucca Mountain. As required by the Nuclear Waste Policy Act, the NRC stands ready to amend its regulations consistent with any forthcoming changes to the EPA standards for Yucca Mountain.

In anticipation of a DOE license application for Yucca Mountain, the NRC has prepared an electronic hearing system to conduct potential public hearings related to potential construction of a high-level radioactive waste repository at Yucca Mountain. An electronic information technology system data base has been developed to catalogue and allow public access to the vast array of complex documents involved. A hearing facility has been constructed near Las Vegas, Nevada.

The NRC staff also has a substantial effort underway in the area of dry cask storage of spent reactor fuel. Storage and transport cask designs continue to be reviewed and certified. Independent Spent Fuel Storage Installations (ISFSIs) continue to be licensed and inspected. The proposed Private Fuel Storage ISFSI in Utah is the subject of an ongoing adjudicatory proceeding. Indeed, our workload related to ISFSIs and dry cask storage will require continued technical review and licensing and inspection resources as the number of licensed ISFSIs will increase from 34 currently to approximately 50 by 2008. The NRC also began development of the Package Performance Study to confirm the suitability of spent nuclear fuel transportation casks. The study will involve testing the integrity of a full-scale transportation rail cask. In addition, NRC is supporting a study by the National Academies' Board on Radioactive Waste Management that is examining radioactive material transportation, with a primary focus on the technical and societal risk of spent fuel transportation.

NRC staff is also continuing to make significant progress in ensuring the safe decommissioning of contaminated sites. During fiscal year 2004, the staff identified several policy issues requiring Commission direction that will help expedite safe decommissioning under NRC's License Termination Rule. The Commission has provided the necessary guidance to the staff for regulatory actions to be taken during fiscal year 2005–2007 under the staff's Integrated Decommissioning Improvement Plan. These regulatory improvements will facilitate decommissioning at existing sites and should reduce problems at future decommissioning sites.

Program management changes will also be completed this year that will improve the efficiency and effectiveness of the program. Finally, we are completing the oversight of the decommissioning of a number of reactor and complex materials sites this year.

INTERNATIONAL PROGRAM

The NRC also carries out an active international program of cooperation and assistance involving thirty-eight countries with which it exchanges nuclear safety information. This program provides health and safety information and assistance to other countries to develop and improve regulatory organizations and overall nuclear safety and security worldwide. The NRC continues to strongly support multilateral programs for enhancing the level of nuclear safety worldwide, and serves in leadership roles on the technical committees that develop and monitor best practices, and in implementing certain treaties and conventions that encourage the wider adoption of basic standards and practices. It is worth noting that we just released the Export and Import Rulemaking, which will enable the U.S. to meet its goal with the G–8 to implement the export-import provisions of the IAEA Code of Conduct by December 2005.

HUMAN CAPITAL

As you know, the NRC is very dependent on a highly skilled and experienced work force for the effective execution of its activities. The Commission has developed and implemented a strategic workforce planning system to identify and monitor its human capital assets and potential critical skills shortages, and to promote employee development, succession planning, and retention. The agency has also implemented two leadership competency development programs to select high-performing individuals and train them for future mid-level and senior-level leadership positions. In addition, the agency has continued to support a fellowship and scholarship program and identify a significant number of diverse, highly qualified entry-level candidates through participation in recruitment events and career fairs.

NRC has developed an agency wide set of strategic human capital management strategies to mitigate and close gaps between available staffing resources and anticipated staffing needs. NRC is utilizing a variety of recruitment and retention incentives and offers a wide range of technical and professional training to attract and retain staff to remain competitive with the private sector.

Additionally, planning for and developing the agency's future leaders is a critical part of our approach for managing human capital. The NRC's strategic long-range human capital planning includes: succession planning (both managerial and technical); partnerships/cooperative ventures with other stakeholders (e.g., academia, other agencies, national laboratories, private groups) to develop talent supply; continuous improvements to recruitment and training processes, such as the NRC legislative proposals submitted to the Congress on Marcn 30, 2005; a robust Knowledge Management Program; and organizational infrastructure improvements that include the rental of office space, workstation configuration and equipment, security clearances, and associated information system needs.

The Commission is very much encouraged by S. 858, the bill recently introduced in the Senate which contains the provisions that would help the NRC to expand the pool of prospective employees who have the skills to carry out the agency's tasks, employ former Federal employees who have the skills that are critical to the performance of the Commission's duties, and encourage institutions of higher education to train their students in the skills needed to carry out NRC's work. We believe these provisions would significantly contribute to assuring the necessary regulatory expertise required by the NRC to accomplish its regulatory mission. We strongly urge the Congress to enact the human capital provisions in S. 858 into legislation.

BUDGET

The NRC proposed a fiscal year 2006 budget of $702 million, which is a budget increase of approximately 5 percent ($32 million) over the fiscal year 2005 budget for essential activities. This budget proposal will allow the NRC to continue to protect the public health and safety, promote the common defense and security, and protect the environment, while providing sufficient resources to address increasing personnel costs and new work. Approximately 55 percent ($17.7 million) of the increase is for the nuclear reactor safety program to strengthen reactor inspection activities and keep pace with licensing needs of existing nuclear reactor facilities. An increase of $2.5 million supports our responsibilities for oversight of certain DOE wasteincidental-to-reprocessing, as required by Section 3116 of the Ronald W. Reagan National Defense Authorization Act of fiscal year 2005. The remaining increase is to fund Federal pay raises and other non-discretionary compensation mid benefit increase.

The NRC's fiscal year 2006 budget includes approximately $69.1 million to support high-level waste activities. These activities include license application review, hearings, and inspection and performance confirmation oversight activities, reflecting DOE's anticipated license application for the Yucca Mountain waste repository in December 2005. The Package Performance Study, to confirm the suitability of spent nuclear fuel transportation casks, is also included.

The NRC's proposed fiscal year 2006 budget request includes $37 million for the NRC's continuing work on new reactor licensing, including review of the three early site permit applications, review of two standard design certification applications, and development and updating of the agency's regulatory structure to accommodate new, advanced reactor designs. The demand for new reactor licensing is now expected to grow more rapidly than previously anticipated and budgeted. As stated previously, the NRC may be faced with a significant increase in its workload for new reactor licensing, including receipt of up to five combined license applications beginning in 2007–2008, which creates additional demands on the NRC. The Commission notes that the House Appropriations Committee provided an increase of $21 million over the agency's budget request to address the increased security workload.

On March 17, 2005, the NRC submitted proposed legislation which would authorize appropriations for fiscal year 2006. The proposed legislation included two provisions related to financing the budget. One would make permanent the NRC's 90 percent fee recovery requirement beginning in fiscal year 2006. Absent this legislation the NRC would only be authorized to collect 33 percent of its budget authority in fees after fiscal year 2005. Another provision would permit the NRC to assess and collect fees from other Federal agencies for licensing and inspection services rather than recovering those costs through annual fees assessed to private sector licensees. We are pleased that both are incorporated in the provisions of S. 858.

LEGISLATIVE NEEDS

The NRC urges the enactment of key legislative provisions needed to augment its oversight of such facilities and materials, and to enhance NRC's effectiveness and efficiency. As indicated earlier, the Commission strongly supports legislation that would contribute to the maintenance of the regulatory expertise required by the NRC to accomplish its regulatory mission. Most of the provisions in question have already been incorporated into legislation introduced in the Senate this year.

Several provisions contained in S. 864, the Nuclear Safety and Security Act of 2005, are particularly important to further enhance the nuclear safety and security of facilities and materials that are regulated by the NRC. They are: (1) authorization of the Commission to allow security personnel engaged in the protection of designated nuclear facifties, radioactive material, and other property owned or possessed by an NRC licensee or certificate holder to possess and use more robust weapons for carrying out their official responsibilities, (2) amendment of the Atomic Energy Act to expand the requirements for fingerprinting, for criminal history record checks, (3) making unauthorized introduction of weapons into NRC-regulated facilities a Federal crime, and (4) making it a Federal crime to sabotage commercial nuclear facilities, fuel, or Commission-designated material or property not previously covered by the sabotage section of the Atomic Energy Act (section 236), and extending coverage to the construction period of all facilities addressed by that section.

In addition, the Commission believes that public health and safety and the promotion of the common defense and security would be enhanced by NRC regulatory jurisdiction over accelerator-produced and certain other radioactive material. Such a provision was included in an omnibus bill that the Commission submitted to the Congress at the end of March of this year, but it has not been incorporated into any of the bills whose provisions are discussed here.

Various provisions that would enhance NRC effectiveness and efficiency are contained in Title II of S. 858, the Nuclear Fees Reauthorization Act of 2005. These include the following: (1) clarification of the period of the license in the case of a combined construction and operating license for a nuclear power plant, (2) elimination of NRC's antitrust review authority with respect to pending or future applications for a license to construct or operate a commercial utilization or production facility, (3) permanent extension of NRC's authority to collect approximately 90 percent of its budget authority in fees, as noted earlier, (4) authorization of NRC to assess and collect fees from other Federal agencies for services provided to them, as noted earlier, and (5) clarification that the existence of an organizational conflict of interest does not bar NRC from entering into a contract or other arrangement for work to be performed at a DOE laboratory, if the Commission determines that the conflict of interest cannot be mitigated and that adequate justification exists to proceed with the arrangement. The NRC strongly supports these provisions.

Key provisions relating to maintaining and improving the NRC's regulatory expertise are contained in Title III of S. 858, as noted earlier. Prominent among these are provisions that would help the NRC to expand the pool of prospective employees who have the skills to carry out the agency's tasks, by enabling the agency to employ former Federal employees who have skills that are critical to the performance of the Commission's responsibilities, and encouraging institutions of higher education to train their students in the skills needed to carry out NRC's work. The Commission strongly supports all the provisions of Title III of S. 858.

S. 858 also contains provisions that would enhance NRC's ability to recruit appropriate individuals for NRC employment. These provisions would permit NRC to purchase promotional items of nominal value; provide transportation, lodging, and subsistence allowances to student interns hired by the NRC; and establish a scholarship and fellowship program to enable undergraduate and graduate students, respectively, to pursue education in science, engineering, or another field of study that the Commission determines to be critical to the NRC's regulatory mission. The Commission also supports the enactment of these provisions.

In addition, the Commission supports the enactment of S. 865, extending the Price-Anderson Act as it applies to NRC licensees.

CONCLUSION

The Commission continues to be committed to ensuring the adequate protection of public health and safety, promoting common defense and security, and protecting the environment in the application of nuclear technology for civilian use. We will continue to address existing and emergency activities within our mandate from Congress in a pro-active and thorough manner.

RESPONSES OF NILS J. DIAZ TO ADDITIONAL QUESTIONS FROM SENATOR INHOFE

Question 1. Last year I asked a question about the potential increase in efficiencies and resource allocation if the NRC were to consolidate the regional offices' functions into the NRC headquarters. Would the NRC function more efficiently if we consolidated the regional functions, keeping the resident inspectors in place? This could eliminate some redundancy in overhead and help provide Headquarters with the experienced staff they need. What have been the results been of that review?

Response. The NRC has considered consolidating the employees at the 4 regions to headquarters. The most recent Commission review on the subject of regional consolidation was conducted in response to the fiscal year 2003 Energy and Water Development Appropriations Act, (House Report 108–10 and Senate Report 107–220), which directed the NRC to report to the Congress on regulatory efficiencies that would be gained by consolidating or eliminating regional offices. The Commission provided a response on June 26, 2003. The NRC's response to the report noted that the Commission believes that, in the context of its mission, a strong regional presence is essential for the effective implementation of the agency's health, safety, and security programs. Reviews were also conducted during the 1994–1995 timeframe, which resulted in the closure of NRC's Region V office in California, and in 1998 and 2002.

The Commission continues to believe that public health and safety are better served with critical NRC expertise located closer to the geographical area where our licensed activities occur. Whether overseeing routine licensed activities or reacting to unforseen circumstances, a regional office can rapidly muster critical resources to a facility when a situation needs immediate attention and time is of the essence. Each of the four regional offices oversee 21 to 32 operating reactors, which enables the NRC to rapidly deploy its personnel in response to incidents and emergencies in four different geographical locations. Homeland security initiatives and objectives provide additional compelling reasons for maintaining the agency's current regional structure. All the regional offices are involved in heightened security, safeguards, and emergency preparedness activities in light of the current threat environment. Region-based inspectors are an essential complement to the resident inspector corps. Members of this group possess specialized expertise to perform more in-depth inspections and assessments in individual program areas, including a licensee's security-related facilities, equipment, procedures, training, and exercises.

The NRC's regional structure aligns well with the Administration's emphasis on close communication with constituents and stakeholders. Regional offices bring NRC closer to the public it serves, giving stakeholders access to NRC officials in their own region of the country, thereby enhancing relationships with local and state officials and helping to ensure openness in its regulatory process. As a result of these interactions with local and state officials, as well as the public, regional staff become more sensitive to specific issues and concerns of interest to those stakeholders. With new reactor siting and construction expected in a few years, the regional offices will play an important role in the inspection of the construction activities, interacting with the local and state governments, and responding to local citizens' concerns.

Finally, although our most recent review is 2 years' old, the Commission is aware of no information that would be contrary to the 2003 report to Congress. The only substantial change is the apparent large increase in housing costs in the Washington, DC, area which would drive up costs and probably result in the loss of many staff at a time when NRC can least afford to lose staff.

The Commission continues to look for efficiencies in other aspects of the operation of its regional offices. For example, the Commission recently consolidated the NRC's inspection and oversight responsibility for all major fuel cycle facilities in its Region II office in Atlanta, while consolidating responsibility for the inspection and licensing of the materials licensees located in Regions I and II in its King of Prussia, Pennsylvania, office.

Question 2. Some witnesses today will express concern with NRC's oversight and enforcement of security requirements at nuclear facilities—what assurances can you provide this committee that not only are you taking the steps to ensure that security standards are robust, but also that the Commission is taking the necessary steps to ensure that these standards that you have set are being met by the licensees?

Response. Nuclear power facilities have long been and continue to be among the most robust and best protected commercial structures in this country. The NRC regulations require that the licensees be able to protect their facilities with high assurance against acts of radiological sabotage or theft of nuclear material by a determined adversary. The Design Basis Threat or DBT provides a reasonable characterization of the threat against which physical security programs are developed. The DBT is based on an extensive analysis of current and projected terrorist capabilities and was arrived at in coordination with the Intelligence Community, law enforcement agencies, and State and local governments. We continuously monitor threats in the United States and abroad and can and will revise the DBT as necessary and appropriate. After the terrorist attacks of 9–11, NRC issued Orders to supplement the DBTs for nuclear power facilities and Category I fuel cycle facilities and will shortly initiate rulemaking to more formally revise the DBTs to reflect the post 9–11 environment.

There are many Federal agencies working on preventing and protecting against terrorist attacks. The significant increase in aviation security since 9–11 goes a long way toward protecting the United States, including nuclear facilities, from an aerial attack. In February 2002, the NRC directed nuclear power plant licensees to develop specific plans and strategies to respond to a wide range of threats, including the impact of an aircraft.

The NRC conducts regular inspections to ensure that reactor licensees are in compliance with NRC security requirements. The agency also has expanded its Force-on-Force exercise program in which it tests the ability of the licensees to defend their facilities against commando-type terrorist attacks. In 2003 and 2004, the NRC completed inspections of licensees' implementation of the power reactor security, access authorization, and fatigue Orders to verify that licensees were complying with these requirements. Beginning in late 2004 and continuing through 2005, the NRC is inspecting licensees' implementation of the DBT and security guard training Orders.

The NRC has permanently assigned resident inspectors at operating power reactor sites who inspect and assess all areas of a licensee's programmatic performance. The NRC also has, at its four regional offices and headquarters office, additional inspectors who possess specialized expertise to perform more in-depth inspections and assessments in individual program areas, including a licensee's security-related facilities, equipment, procedures, training, and exercises. The results of inspections and licensee performance indicators are integrated and evaluated against performance metrics under the NRC's Reactor Oversight Program.

In the area of nuclear materials security, the NRC has thoroughly reevaluated its safeguards and security programs since 9–11. To date, the NRC has issued over 16 different categories of Orders and Confirmatory Action Letters covering hundreds of licensees and actions involving radioactive materials of greatest concern. The emphasis of this effort has been on preventing the use of radioactive materials that have the potential to pose a risk to public health and safety in a radiological dispersal device or a radiological exposure device (RDD/RED). The Commission, in coordination with our Department of Energy (DOE) colleagues, has taken the following actions to improve the security of radioactive sources of greatest concern:

- Issued advisories to licensees to enhance security measures;
- Issued the DOE/NRC Interagency Working Group Report on RDD/REDs, which defined threshold quantities for radioactive materials that are the highest risk and have a potential for malevolent use;
- Worked with the Departments of Energy and State and the international community to reach agreement on which radioactive materials and sources are of the greatest concern, consistent with the International Atomic Energy Agency (IAEA) Code of Conduct on the Safety and Security of Radioactive Sources;
- Approved a final rule amending its export and import regulations, in coordination with the Departments of State, Energy, and Homeland Security, to impose more stringent controls over the Category I and Category II materials defined by the IAEA Code of Conduct;
- Begun development of a National Source Tracking System to track radioactive materials of greatest concern specified in the IAEA Code of Conduct on a permanent basis; and

• Developed an interim data base of Category I and II radioactive sources for both NRC and Agreement State licensees which will be maintained until the National Source Tracking System is complete.

Question 3. The NRC has taken a number of steps to increase security at power plants. With this latest upgrade of the DBT, is it correct to say that you have asked all that should be asked of licensees under the current threat condition? It is vital that we provide certainty to the licensees so that they can implement the requirements and train for these conditions. Can you assure me that we are at a stage where that certainty exists?

Response. The NRC has required that its licensees be able to protect nuclear power plants with high assurance against acts of radiological sabotage by a determined adversary. The Design Basis Threat or DBT provides a reasonable characterization of the threat against which physical security programs are developed. The DBT is based on an extensive analysis of current and projected terrorist capabilities and was arrived at in coordination with the Intelligence Community, law enforcement agencies, and State and local governments. We continuously monitor threats in the United States and abroad and can and will revise the DBT as necessary and appropriate. After the terrorist attacks of 9–11, NRC issued Orders to supplement the DBTs.

With the comprehensive actions to enhance security since September 2001, the Commission believes it has now achieved a level of greater certainty and stability in expectations for licensees as well as high assurance of protection of nuclear power plants. Accordingly, the Commission is proceeding to codify DBT enhancements for current and future licensees by rulemaking.

The NRC took a multi-pronged approach to enhance security at nuclear power plants, including:

• Ordered plant owners to sharply increase physical security programs to defend against a more challenging adversarial threat;

• Required more restrictive site access controls for all personnel; Enhanced communication and liaison with the Intelligence Community;

• Ordered plant owners to improve their capability to respond to events involving explosions or fires;

• Enhanced readiness of security organizations by strengthening training and qualifications programs for plant security forces;

• Required vehicle checks at greater stand-off distances;

• Enhanced Force-on-Force exercises to provide a more realistic test of plant capabilities to defend against an adversary force; and

• Improved liaison with Federal, State, and local agencies responsible for protection of the national critical infrastructure through integrated response training.

The major requirements were implemented by licensees on October 29, 2004. Those requirements include physical security improvements necessitated by the supplemented DBT and Orders. The NRC routinely inspects the licensee's physical security measures as part of its baseline inspection program and conducts Force-on-Force exercises to assess the effectiveness of licensee's security programs. In addition, the NRC has initiated an oversight program to confirm that the measures implemented and pertinent mitigative strategies are in place. The program consists of 3 phases: inspection of the February 25, 2002 Orders, site-specific assessment of spent fuel pools, and site-specific assessments of reactors. The final phase will be completed in June 2006.

Question 4. It is my understanding that the NRC has been moving ahead with its plan to change its regulatory process to one that is risk-informed and performance-based. This is a process that is strongly supported by industry as well as by some of your critics. Would you explain to me where the NRC is at regarding this process and are you moving quickly on fully implementing this process change?

Response. The NRC is making significant strides toward its objectives of fully integrating risk-informed regulation into its safety decisionmaking framework, most notably through efforts to risk-inform its Reactor Oversight Process and reactor and materials regulations. By providing more safety-focused regulations and more objective processes, which the NRC initiated in the mid-1990s through the probabilistic risk assessment (PRA) Implementation Plan and PRA Policy Statement, the NRC can and is achieving significant improvements in safety.

Recent examples include:

(1) In June 2004, the NRC amended its fire protection requirements for nuclear power plants to allow licensees to adopt a new set of requirements that incorporates risk insights. The rule endorses the National Fire Protection Association Standard No. 805, "Performance-Based Standard for Fire Protection for Light Water Reactor

Electric Generating Plants, 2001 Edition." The new rule maintains safety and provides flexibility to existing requirements.

(2) In November 2004, the NRC amended the regulations to provide an alternative approach to establishing requirements for treatment of structures, systems, and components (SSCs) for nuclear power reactors using a risk-informed method for categorizing SSCs according to their safety significance. The categorization process uses a blend of deterministic and risk insights to develop an integrated assessment of the safety significance of particular SSCs and then specifies requirements commensurate with the significance.

(3) Currently, the Commission is considering the merits of a proposed amendment to the regulations that would provide a risk-informed alternative to the current requirements associated with the maximum reactor coolant system pipe break size that must be considered within the design basis of the plant under 10 CFR 50.46 (Emergency Core Cooling System Acceptance Criteria). The amendment is structured to allow and encourage operational as well as design safety improvements.

(4) In the nuclear material and waste arenas, the NRC has developed a generic framework for risk-informed regulation which facilitates identifying areas where risk-informed regulatory changes would be beneficial. This approach was designed to focus agency and licensee resources on areas commensurate with their importance to safety.

(5) In the area of decommissioning, guidance is being developed to use a graded approach to institutional controls, more realistic exposure scenarios, and risk-ranking of facilities for inspections.

(6) In the area of high-level waste, the NRC has produced the Yucca Mountain Review Plan to provide guidance for performing a risk-informed review of a license application and a Risk Insights Baseline Report as a common reference for risk-informed issue resolution.

(7) The risk-informed and performance-based revision of Subpart H, "Additional Requirements for Certain Licensees Authorized to Possess a Critical Mass of Special Nuclear Material," to 10 CFR Part 70, "Domestic Licensing of Special Nuclear Material," requires existing fuel cycle licensees to perform Integrated Safety Analyses of their facilities.

(8) A multi-phased risk-informed review of nuclear byproduct materials regulatory programs has resulted in revision of the inspection program to concentrate on higher risk activities; and revisions to regulations and licensing guidance are underway.

(9) The Commission, realizing the regulatory experience gained and utilizing the extensive body of existing know how, instructed the staff, under Staff Requirements Memorandum of May 9, 2005, to proceed with risk-informing 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

Question 5. During the hearing, I asked you to comment on GAO recommendations and what the NRC has done in response.

Response. At the Senate Environment and Public Works Committee oversight hearing held on May 26, 2005, GAO testified that based on its analyses, it believes NRC has improved its operations in recent years in a number of ways. Nevertheless, GAO's testimony indicated that NRC needs to take additional actions to better fulfill its mission, and that it had made associated recommendations for improvement in seven reports issued during the past 2 years.

NRC generally agrees with GAO that some improvements are appropriate, and we did disagree with some of GAO's findings and recommendations for various reasons. In each case, NRC's rationale is documented in written comments on the draft reports, and in the written statements to Congress submitted in accordance with 31 U.S.C. 720 on final report recommendations. In addition, NRC has described the progress made in addressing recommendations in its annual reports to Congress as required by Section 236 of Public Law 91–510, the "Legislative Reorganization Act of 1970."

The enclosure and its attachments summarize NRC's comments on specific report recommendations from the seven reports mentioned in GAO's testimony on May 26, 2005, NRC comments on the draft reports where applicable, and what NRC has done in response to the report recommendations.

Enclosure: GAO Reports and NRC Responses to Recommendations

GAO Reports and NRC Responses to Recommendations

GAO–03–804, NUCLEAR SECURITY: FEDERAL AND STATE ACTION NEEDED TO IMPROVE SECURITY OF SEALED RADIOACTIVE SOURCES, AUGUST 6, 2003

Draft Report: NRC provided comments to GAO in a letter from William D. Travers, NRC, to Robert A. Robinson, GAO, dated June 26, 2003 (Attachment 1).

In this letter, we informed GAO that the draft report did not fully present either the current status of NRC efforts to improve the security of high-risk radioactive sources or the large effort that NRC had devoted to this issue over the prior 18 months. We also informed GAO that the draft report reflected a limited outline of NRC's existing statutory framework and did not recognize that several recommendations would require statutory changes at both Federal and State levels. Our letter provided specific detail on the Commission's accomplishments and plans to improve the security of high-risk radioactive sources.

Final Report: NRC's written response required by 31 U.S.C. 720 was provided to Rep. Tom Davis, et al., on February 4, 2004 (Attachment 2). In this letter, we informed Congress that NRC agreed with several of the recommendations and that we had already taken steps to implement those recommendations (and in several cases, implementation occurred before the GAO performed its review) as improvements in our regulatory programs. However, as stated in our June 26, 2003 comments on the draft report, we reiterated that the final report did not fully present either the current status of NRC efforts to improve the security of high-risk radioactive sources or the large effort we devoted to this issue prior to GAO publishing the report. We stated our continued belief that the level of health risk posed by the various sources should be the determining factor for application of security measures, and that other factors, such as psychological, social, and economic costs, can vary from region to region and over time and, thus, provide a less stable measure for establishing necessary security measures. The letter's enclosure provided our responses to the specific recommendations of the report.

Annual Reports to Congress: Since providing our written statement to Congress on the final report, NRC's has reported twice to Congress on the progress of our actions in response to the report recommendations, as required by Section 236 of Public Law 91–510. Please refer to our CY 2003 report (Attachment 13) and CY 2004 report (Attachment 14).

GAO–03–752, NUCLEAR REGULATORY COMMISSION: OVERSIGHT OF SECURITY AT COMMERCIAL NUCLEAR POWER PLANTS NEEDS TO BE STRENGTHENED, SEPTEMBER 4, 2003

Draft Report: NRC provided comments to GAO in a letter from Nils J. Diaz , NRC to James Wells, GAO dated August 7, 2003 (Attachment 3). In this letter, the Commission informed GAO of its concern that the draft report did not provide an appropriately balanced or very useful perspective of the NRC's role in ensuring nuclear power plant security. The Commission recognized that the report accurately described some of the legal challenges that exist, but pointed out that it failed to fully recognize the significant effort the NRC has made in the post-September 11, 2001 environment to strengthen what was already a very robust security program. The Commission also commented that the draft report's emphasis on non-cited violations as "minimizing" the significance of security problems was a serious misrepresentation and that the individual anecdotal issues noted in the report were appropriately treated within NRC's enforcement process. This letter also noted that the key issues identified in GAO's draft report were relatively minor, that the issues had already been identified by the NRC before the review was initiated, and that corrective actions for these issues either had been completed or were nearly complete. On August 15, 2003, NRC provided more detailed comments on the draft report to address issues of correctness, currentness, and clarity (Attachment 4).

Final Report: NRC's written response required by 31 U.S.C. 720 was provided to Rep. Edward Markey, et al., on October 23, 2003 (Attachment 5). In this letter, we informed Congress that the GAO report misrepresented the high level of security at these nuclear power plants by mischaracterizing NRC's inspection program and has not recognized the substantial enhancements of security at NRC-licensed facilities, and that it did not adequately acknowledge the extensive actions taken to enhance security and the role NRC's oversight program played in achieving these substantial enhancements since the events of September 11, 2001. We also informed Congress that despite considerable NRC effort to support GAO in the performance of its study, we were concerned that the report did not provide a balanced perspective and did not recognize the breadth and effectiveness of NRC's security oversight program.

Annual Reports to Congress: Since providing our written statement to Congress on the final report, NRC's has reported twice to Congress on the progress of our actions in response to the report recommendations, as required by Section 236 of Public Law 91–510. Please refer to our CY 2003 report (Attachment 13) and CY 2004 report (Attachment 14).

GAO–05–1064T, NUCLEAR REGULATORY COMMISSION: PRELIMINARY OBSERVATIONS ON EFFORTS TO IMPROVE SECURITY AT NUCLEAR POWER PLANTS, SEPTEMBER 14, 2004

On September 14, 2004, GAO and NRC staff testified at a House Subcommittee on National Security, Emerging Threats, and International Relations hearing on its preliminary observations regarding NRC's efforts improve security at nuclear power plants, particularly with respect to capabilities to defend against a terrorist attack.

At that time, NRC testified that even prior to the terrorist attacks, NRC had required nuclear power plants to have security programs that included sophisticated surveillance equipment and armed response forces, and that these already robust security measures had since been supplemented with increased security patrols, additional security posts, increased vehicle standoff distances, improved coordination with law enforcement, and other measures. NRC also informed Congress that it had completed an extensive set of vulnerability assessments and strengthened safety-related mitigation procedures and strategies for NRC-licensed activities involving radioactive materials and nuclear facilities and that it had also revamped its force-on force mock-attack program to test licensees' defense against new terrorist realities. While this GAO testimony required no specific response from NRC, in a letter dated October 14, 2004, from NRC Chairman, NRC, to Rep. Christopher Shays, et al. (Attachment 6), NRC addressed some of the Subcommittee Members' concerns discussed at the hearing on the security of NRC-regulated nuclear facilities and radioactive materials.

GAO–04–32, NUCLEAR REGULATION: NRC NEEDS MORE EFFECTIVE ANALYSIS TO ENSURE ACCUMULATION OF FUNDS TO DECOMMISSION NUCLEAR POWER PLANTS OCTOBER 30, 2003

Draft Report: NRC provided comments to GAO in a letter from William Travers, NRC, to James Wells, GAO, dated October 3, 2003 (Attachment 7). In this letter, we informed GAO that we did not agree with its recommendations and provided detailed rationale: (1) NRC's practice with respect to analyzing decommissioning funds where nuclear power plants have co-owners is consistent with its internal guidance; (2) the NRC has a methodology that is different from GAO's for assessing whether funds are being accumulated appropriately; and (3) the NRC's practice is to review licensees who have not accumulated sufficient funds on a case-by-case basis.

Final Report: NRC's written response required by 31 U.S.C. 720 was provided to Sen. Susan Collins, et al. on February 10, 2004 (Attachment 8). In this letter, we informed Congress that NRC has had established a method that was effective in analyzing whether owners are accumulating sufficient funds for decommissioning. Moreover, we reported that if NRC determined, based on available information, that an owner did not appear to be on track to accumulate sufficient funds for decommissioning, or that an owner's present decommissioning fund balance did not appear to be adequate, NRC had a procedural framework it would use to require licensees to take appropriate corrective actions. We advised Congress that contrary to GAO's recommendation, NRC did not believe it was necessary to establish specific criteria for responding to unacceptable levels of decommissioning funding assurance, considering the complexity and range of circumstances that may arise with any given owner, particularly those who are subject to the jurisdiction of State regulatory authorities and the Federal Energy Regulatory Commission. In addition, we indicated that the implementation of specific criteria was not necessary to protect public health and safety.

Annual Report to Congress: Since providing our written statement to Congress on the final report recommendations, to which we did not agree, NRC has not taken additional action. Therefore, this report's recommendations were not addressed in our last report (CY 2004, Attachment 14) to Congress on the progress of our actions in response to the report recommendations.

GAO–04–654, NUCLEAR REGULATION: NRC'S LIABILITY INSURANCE REQUIREMENTS FOR NUCLEAR POWER PLANTS OWNED BY LIMITED LIABILITY COMPANIES, MAY 28, 2004

Draft Report: NRC provided comments to GAO in a letter from William Travers, NRC, to James Wells, GAO, dated April 29, 2004 (Attachment 9). In this letter, we informed GAO that the draft report accurately reflected the insurance system for nuclear power plants. GAO determined that of the 103 operating nuclear power plants, 31 were owned by 11 limited liability companies and found that NRC requires all licensees for nuclear power plants to show proof that they have the primary and secondary insurance coverage mandated by the Price-Anderson Act. In addition, GAO found that NRC does not treat limited liability companies differently

than other licensees with respect to the Price-Anderson Act's insurance requirements.

Final Report: This report had no recommendations for NRC action, therefore, a written response from NRC was not required by 31 U.S.C. 720.

Annual Report to Congress: This report had no recommendations for NRC action. Therefore, it is not addressed in our last report (CY 2004, Attachment 14) to Congress on the progress of our actions in response to GAO report recommendations.

GAO–04–415, NUCLEAR REGULATION: NRC NEEDS TO MORE AGGRESSIVELY AND COMPREHENSIVELY RESOLVE ISSUES RELATED TO THE DAVIS-BESSE NUCLEAR POWER PLANT'S SHUTDOWN, MAY 17, 2004

Draft Report: NRC provided comments to GAO in a letter from William Travers, NRC, to James Wells, GAO, dated May 5, 2004 (Attachment 10). In this letter, we informed GAO that the draft report did not appropriately characterize, or provide a balanced perspective on, NRC's actions surrounding the discovery of the Davis-Besse reactor vessel head condition or NRC's actions to incorporate the lessons learned from that experience into our processes. We also told GAO that NRC also does not agree with two of the report's recommendations, and we provided detailed explanations. Our letter also stated that while there were a number of factual errors in the draft report, we had agreed with many of the findings, most of which we believed were similar to the findings of NRC's Davis-Besse Lessons-Learned Task Force (LLTF). We also indicated that NRC had made significant progress in implementing actions recommended by the LLTF and expected to complete implementation of more than 70 percent of them, on a prioritized basis, by the end of CY 2004. Further, we stated that semiannual reports tracking the status of these were and would continue to be provided to the Commission until all items were completed, and then a final summary report would be issued.

Final Report: NRC's written response required by 31 U.S.C. 720 was provided to Rep. Tom Davis, et al., on September 2, 2004 (Attachment 11). In this letter, we informed of Congress of actions we had taken to address the report's recommendations, indicating that we believed that actions we had already taken with respect to two of the recommendations relating to determining the resource implications of the LLTF's and long-term tracking of implementation of the LLTF's recommendations and those of future task forces.

Annual Reports to Congress: Since providing our written statement to Congress on the final report, NRC's has reported once to Congress on the progress of our actions in response to the report recommendations, as required by Section 236 of Public Law 91–510. Please refer to our CY 2004 report (Attachment 14).

GAO–05–339, NUCLEAR REGULATORY COMMISSION: NRC NEEDS TO DO MORE TO ENSURE THAT POWER PLANTS ARE EFFECTIVELY CONTROLLING SPENT NUCLEAR FUEL, APRIL 8, 2005

Draft Report: NRC provided comments to GAO in a letter from Luis Reyes, NRC, to James Wells, GAO, dated March 25, 2005 (Attachment 12). In this letter, we informed GAO that NRC had found the draft report to be well written and balanced, and that NRC had generally agreed with the conclusions reached by GAO. However, we stated that the report did not sufficiently acknowledge NRC actions in the material control and accounting (MC&A) area that were already ongoing prior to the commencement of the GAO review. In addition, we commented that the report did not make clear that the problems at Vermont Yankee were identified as a direct result of NRC inspection activities.

Our letter emphasized that we believed the likelihood that an adversary could steal spent fuel from a spent fuel pool or storage cask was extremely low, given the security and radiation protection measures in place and the ease of "detect-ability" and intense, physically disabling radiation from spent fuel. We agreed with the conclusion that licensees' efforts to account for and control spent fuel were uneven; however, we pointed out that this knowledge also came from the NRC inspections and responses to a temporary inspection effort, as did the knowledge that the biggest problem was accounting for and controlling pieces of spent nuclear fuel, as opposed to assemblies. We stated that performance-based approaches were often more effective and efficient at achieving the desired outcomes than prescriptive approaches. Consequently, we believe that dictating how licensees were to meet the MC&A requirements was not necessarily the most effective and efficient approach.

With respect to GAO's findings related to the timeliness of NRC actions, we commented that in the broader context of all NRC activities that needed to occur since the events of September 11, 2001, work in this area had been postponed by the need to devote NRC's limited resources to security and radiological protection areas re-

quiring more immediate attention and that the report should balance its discussions by crediting NRC for making prioritized decisions based on a variety of identified factors. Although the report identifies an important accounting issue for fuel rod segments, it did not, in our view, identify a security or safety issue because there is no reason to conclude that any of the missing fuel segments were removed for any malevolent purposes.

Final Report: NRC's written response required by 31 U.S.C. 720 has been developed and is under the Commission's review. We expect to issue it to Congress in June 2005.

Annual Reports to Congress: After providing our written statement to Congress on the final report, NRC will update Congress annually on the progress of our actions in response to the report recommendations, as required by Section 236 of Public Law 91–510.

Attachments:

Attachment 1: Ltr W. Travers, NRC, to R. Robinson, GAO, dtd 6/26/03
Attachment 2: Ltr N. Diaz, NRC, to Rep. T. Davis, et al., dtd 2/4/04
Attachment 3: Ltr N. Diaz, NRC, to J. Wells, GAO, dtd 8/7/03
Attachment 4: Ltr W. Travers, NRC, to J. Wells, GAO, dtd 8/15/03
Attachment 5: Ltr N. Diaz, NRC, to Rep. E. Markey, et al., dtd 10/23/03
Attachment 6: Ltr N. Diaz, NRC, to Rep. C. Shays, et al., dtd 10/14/04
Attachment 7: Ltr W. Travers, NRC, to J. Wells, GAO, dtd 10/03/03
Attachment 8: Ltr N. Diaz, NRC, to Sen. S. Collins, et al., dtd 2/10/04
Attachment 9: Ltr W. Travers, NRC, to J. Wells, GAO, dtd 4/29/04
Attachment 10: Ltr W. Travers, NRC, to J. Wells, GAO, dtd 5/5/04
Attachment 11: Ltr N. Diaz, NRC, to Rep. T. Davis, et al., dtd 9/2/04
Attachment 12: Ltr L. Reyes, NRC, to J. Wells, GAO, dtd 3/25/05
Attachment 13: Ltr N. Diaz, NRC, to Sen. Voinovich, et al., dtd 4/6/04
Attachment 14: Ltr N. Diaz, NRC, to Sen. Voinovich, et al., dtd 4/27/05

RESPONSES BY NILS J. DIAZ TO ADDITIONAL QUESTIONS FROM SENATOR JEFFORDS

Question 1. The National Research Council report also highlights the continuing security concerns presented by spent nuclear fuel pools. About a third of the nuclear facilities are designed with the spent fuel pool above ground, including the Vermont Yankee facility in my state. Though the Commission will certainly have to discuss these issues further, what immediate steps has the Commission taken [to] address the risks identified in the report posed by above ground pool storage?

Response. After 9–11, the NRC conducted detailed site-specific security assessments at four selected sites. While those studies were underway, the NRC took direct regulatory action to enhance safety and security at nuclear power plants and spent fuel pools. In February 2002, the NRC ordered the nuclear power industry to develop and implement mitigation strategies to deal with structural or fire damage to a facility. Furthermore, the NRC also decided that additional site-specific inspections and site-specific studies of mitigation capabilities should be conducted at all sites, including all spent fuel pools to enhance protection capabilities further. All site-specific spent fuel pool assessments are scheduled to be completed by the end of this calendar year.

In conducting the detailed site-specific security assessments studies, the NRC drew on national experts from several U.S. Department of Energy (DOE) laboratories using state-of-the-art structural and fire analyses. The NRC also enhanced its ability to predict realistically accident progression due to the loss of large areas of reactor sites from fires and explosions and consequent releases of radiation to the environment. These studies confirm that it is very unlikely that there would be a significant release of radioactivity from a deliberate attack of a large commercial aircraft on a spent fuel pool at a nuclear reactor site.

In addition, these Orders addressed both in-ground and above-ground spent fuel pools. The NRC issued a letter on July 29, 2004, with a sensitive unclassified Safeguards Information enclosure specifying certain mitigative measures for licensees to take to enhance their ability to restore and maintain effective fuel cooling if the pool or the overlying structure were severely damaged. The NRC met with power reactor licensees in February 2005 on the NRC's spent fuel pool mitigation measures. At the end of February 2005, power reactor licensees were given until May 2005 to respond to the additional specific recommendations. The NRC staff is currently evaluating these responses to ensure they meet our expectations. The staff will conduct inspections in September and October of this year. A final report is due to the Commission in December. The NRC continues to evaluate power reactor security, including spent fuel pool security, in Force-on-Force exercises, which the NRC will carry

out at least once every 3 years at each of the power reactor sites. Licensee actions to address those measures will be inspected by the NRC staff later this year.

Question 2. The last chapter of the National Research Council report suggests that the Commission's controls on information may be inhibiting security improvements. It states that representatives of the study team, and even of industry were frustrated by the Commission's restrictions on sharing data that could help with "early actions to address identified vulnerabilities." The panel stated it was " unable to examine several important issues" related to the security of spent fuel, in part "because it was unable to obtain needed information from the Nuclear Regulatory Commission." I know the real need to protect classified security information, but would you describe for the Committee your general view about the types information that must be shielded from the companies charged with the security of nuclear material and what information should be given to them.

Response. The Commission carefully weighs all instances where authorized stakeholders with a need-to-know request access to sensitive information. The Commission's policy is to ensure that the NRC is striking the right balance between making information publicly available and withholding information for security reasons. As a result, the Commission established an internal task force to review information security and protection, including classified information, sensitive unclassified Safeguards Information, and other information that should be withheld from public disclosure. Representatives of this task force interacted with appropriate members of the executive branch in conducting its review and has made recommendations for Commission consideration.

The NRC agrees that maintaining this balance is vital to maintaining public confidence while ensuring the appropriate levels of security for licensees. The Commission has taken prompt action since the events of September 11, 2001, in increasing the availability of classified and Safeguards Information with persons who have a need-to-know, are authorized access, and can protect the information. Although there was some difficulty in obtaining security clearances for industry personnel to the right level, the NRC now has in place security clearances for a limited number of individuals at each power plant site to enhance prompt communication of classified information. To date, each site has an average of three individuals cleared for this purpose. Where the Commission has independent authority over dissemination of sensitive information (e.g., Safeguards Information), the NRC has moved forward expeditiously. In other areas (e.g., National Security Information), the NRC has worked carefully with industry and other Federal agencies to provide greater access to this information.

Question 3. The Congressional request for the recent National Academy study was prompted by conflicting claims about the safety and security of spent nuclear fuel at power plants done by researchers at Princeton in 2003. Do you support NAS's call for the development of "maximum credible threat scenarios" that incorporate the use of outside expert judgment?

Response. While the NRC is in broad agreement with the principal findings of the NAS study, the NRC holds a different view regarding the NAS recommendation of "maximum credible scenarios" as the preferred basis for assessing safety and security. The NRC considers that the use of maximum-credible scenarios, particularly as described in the NAS study, would not be an effective approach. This method would direct analyses at an overly large scope of scenarios, including some unrealistic scenarios. Rather, the NRC believes it should focus its resources, as well as those of its regulated licensees, on a realistic spectrum of credible scenarios. Additionally, the NRC considers that analysis of "bounding" or unrealistic scenarios can lead to a misinterpretation of the actual risk and that this can cause confusion among the public and other stakeholders.

With respect to using outside expert judgment, NRC works closely with the Department of Homeland Security, FBI, and other intelligence agencies to continually evaluate information from experts in the homeland security, law enforcement and intelligence communities to determine the threat to facilities licensed by the NRC, including those storing spent nuclear fuel, and evaluating potential risks and vulnerabilities associated with these facilities. The NRC has also involved outside experts from national laboratories onsite-specific studies associated with spent fuel pool protection capabilities.

Question 4. For NRC Chairman Nils Diaz—I would like to give you an opportunity, Chairman Diaz, to address the April 7, 2005 Matthew Wald New York Times story. In that story, you are quoted as having said that spent fuel pools are "not easily breached structures," and that after an attack they would be easy to cool with "a couple of fire hoses." These statements caused concern in my state both among the public and among some technical experts regarding whether the cooling system

you describe would be sufficient or able to be deployed in the event of an attack. Do you still stand by this statement? Do you believe that additional analysis is warranted to determine appropriate methods for fuel pool fire response? Is the Commission considering additional guidance or regulations regarding cooling systems?

Response. Yes. In a publicly released version of the National Academy of Sciences (NAS) report on the safety and security of commercial spent nuclear fuel storage, the NAS panel references a calculation which suggested that 50–60 gallons per minute of water sprayed over an entire pool would likely be adequate to prevent a zirconium cladding fire in a loss-of-pool coolant event. The capacity of "a couple of fire hoses" would easily provide much more than that amount of water, with redundancy.

The NRC recognizes the concern regarding the environment in which such strategies would have to be implemented. Therefore, we have advised our licensees to consider the potential for hostile environments, including large fires, extreme radiation environments, and the presence of armed adversaries, in developing procedures to implement such strategies. The NRC has provided guidance to licensees on spent fuel management techniques in July 2004 and February 2005. Furthermore, additional plant-specific assessments and analyses will be completed for all U.S. nuclear power plants by November 30, 2005. These analyses are intended to confirm the effectiveness of previously required mitigation capabilities and are expected to identify other appropriate and redundant methods to effectively cool the spent fuel pool.

RESPONSES BY NILS J. DIAZ TO ADDITIONAL QUESTIONS FROM SENATOR LAUTENBERG

Question 1. Though the NRC has improved its oversight of the industry in recent years, why is it that the Inspector General, the GAO, interest groups and whistleblowers, continue to highlight safety issues? Is the NRC really committed to a "Safety Conscious Work Environment?"

Reponses. Yes, the NRC is fully committed to ensuring a Safety Conscious Work Environment (SCWE) at all of our licensed facilities. Safety issues do arise at nuclear power plants, although the frequency and radiological significance of these issues have decreased over the years. Many of these issues are found through NRC's strict oversight, and others are identified by licensees. We take each one seriously, and take measures to prevent recurrence. We expect our licensees to do the same. The NRC and its nuclear power plant licensees continue to maintain a record of performance without injury to a member of the public from a radioactivity release from a nuclear power plant.

Highlighting safety issues to the NRC is consistent with the agency's 1996 Policy Statement definition of SCWE as a work environment where "employees feel free to raise safety concerns, both to their management and to the NRC, without fear of retaliation." Employees are also encouraged to raise their concerns to their employers either prior to or contemporaneously with coming to the NRC. The NRC encourages employees to come to the NRC at any time they believe the Commission should be aware of their concerns. The agency is in the process of developing both guidance to the industry concerning establishing and maintaining a SCWE, as well as guidance to NRC inspection staff to monitor and assess the SCWE better, as one attribute of Safety Culture. An example of the agency's efforts in this area is the recent focus of the NRC on the work environment at Salem and Hope Creek.

The NRC staff conducted in-depth interviews between October 2003 and June 2004 of over 60 current and former Salem/Hope Creek employees from various levels of the organization. The review also considered the inspection and assessment records over the past several years, as well as allegations involving Salem and Hope Creek. Although no serious safety violations were identified, the NRC found weaknesses in the licensee's corrective action program and management efforts to establish an environment where employees are consistently willing to raise safety concerns. The NRC is continuing to provide close oversight of the Salem and Hope Creek stations to monitor and assess SCWE.

Question 2. The Government Accountability Office has found that the NRC has "no plans to address the systemic weaknesses that allowed" the near disaster at Davis-Besse to occur in 2002. What *is* being done within the NRC to prevent the lax oversight which occurred at Davis-Besse from occurring again?

Response. The NRC has addressed the issues that allowed the significant vessel head degradation at the Davis-Besse power plant. Among other things, the NRC required inspection of reactor vessel heads at all pressurized-water reactors. The measures implemented will prevent recurrence of reactor vessel and vessel head degradation from all nuclear power plants in the U.S.

In response to the Davis-Besse reactor vessel head degradation and subsequent Davis-Besse Lessons Learned Task Force (LLTF) recommendations, the NRC has implemented numerous changes to our regulatory processes and programs, and we plan to take additional actions. The changes to the inspection and operating experience programs will have the most systematic impact. Examples of some significant changes are provided below.

The implementation of the Davis-Besse LLTF recommendations included improved Reactor Oversight Process (ROP) management guidelines, revisions and additions to inspection procedures, and inspector training and qualification enhancements. The changes to the program management aspects of the ROP include new guidance for managing NRC resources devoted to plants that are in an extended shutdown as a result of performance issues to ensure there will be less impact on routine oversight at other plants. Also, to ensure continuity of regulatory oversight by certified inspectors, the staff developed and issued a site staffing metric to monitor permanent resident and senior resident staffing at reactor sites, and established the criterion of maintaining a minimum of 90-percent coverage. The Regional staffs have conducted benchmarking reviews based on Davis-Besse LLTF recommendations to identify "best practices" that can be consistently applied in ROP activities.

The NRC has made several changes to the ROP to enhance the NRC's ability to detect declining plant performance, including the specific issues identified at Davis-Besse. The NRC inspection program procedures have been revised to increase evaluation of licensee programs and actions relating to long-standing unresolved problems. Several inspection procedure changes were made to address the reactor vessel head and boric acid inspections. The procedures for monitoring inspection activities during refueling outages have been updated, as have procedures that evaluate licensees' programs and processes to detect, monitor, and take corrective actions for adverse trends in reactor coolant system leakage.

The NRC inspector training program has been enhanced by a Web-based system that provides more timely dissemination of information to the inspection staff, and a method for individual study. New training modules were developed to address lessons learned from the Davis-Besse event such as the effects of boric acid corrosion and the importance of maintaining a questioning attitude toward potential safety issues. The latter training module used the case of the Columbia space shuttle accident to reinforce this message. There have been several recent examples of an improved questioning attitude. At other plants, resident inspectors have identified a peeling paint condition inside containment, a turbine building flooding issue, and a previously unanalyzed condition regarding a crane used to move the reactor vessel head at their respective sites.

In a related effort responding to the Davis-Besse LLTF recommendations, the NRC launched a revised operating experience program in January 2005. The new program systematically collects, communicates, and evaluates operating experience and has substantially advanced the use of information technology in making operating experience information available. There is a new powerful data base for managing all reported events and a new operating experience information gateway that consolidates a large collection of individual data bases and Web sources of information onto a single Web access page. Ready access to this information will be a valuable help to NRC inspectors in planning and conducting their inspections, and to other NRC staff in conducting licensing reviews and rulemaking.

Additionally, as a result of the Davis-Besse experience, the NRC has improved internal communications. To ensure effective communication among inspectors and NRC management, important elements of communication activities as well as regional communications best practices were identified and shared throughout the agency. These elements and best practices are being reviewed and adopted, as appropriate, by the regional offices.

Question 3. What is the NRC doing to encourage people with safety concerns to speak up and how are "whistleblowers" being protected and supported by the agency? Were any "whistleblowers" invited to speak at today's hearing? What message does it send that they were/were not?

Response. The NRC encourages its employees to raise concerns through its Open Door Policy, Generic Safety Issues program, non-concurrence process, the Differing Professional Opinion (DPO) program, and the Office of Inspector General (OIG) Hotline. The NRC recently initiated a revised DPO program which further encourages employees to speak up and make differing views known. The position of a DPO Program Manager was established to improve implementation, administration, communication, and assessment of the program. The DPO program encourages employees to raise issues or concerns involving technical, legal or policy issues to their management. The revised program reemphasizes the importance of two-way communication between staff and management as an important element in the informal resolu-

tion of concerns before a concern reaches the DPO threshold. The DPO program also emphasizes employee confidentiality, protection from retaliation in any form for expressing a differing opinion, and recognition and awards for employees who raise concerns through the DPO program.

The NRC constructed an internal *Employee Concerns* web site, which highlights the various programs where employees can voice their concerns on a variety of areas and includes contact names and numbers of those to whom concerns may be addressed. The agency also improved its leadership training, which sets expectations for managers and institutionalizes the concept that leadership training and skills will be an ongoing agency focus. Additional management training on the DPO program is being developed.

Consistent with the Notification and Federal Employee Anti-Discrimination and Retaliation Act of 2002 (No Fear Act), the NRC provides information to all employees about their rights, protections, and remedies under whistleblower and anti-discrimination and protection laws, as well as NRC's policies about appropriate disciplinary action for engaging in prohibited personnel activities. Employees are encouraged to familiarize themselves with this information on the *Whistleblower and Anti-Discrimination Rights* internal web page. All supervisors are required to receive training on whistleblower protections and the prevention of prohibited practices.

Finally, the NRC has invited employees who have dissenting views to speak at various forums, including Commission meetings, to ensure that their views are encouraged and heard. We believe this sends a positive message that employees are encouraged to raise their concerns in an open and candid environment.

Question 4. My constituents are deeply concerned about a repeat of a September 11th style attack—in which nearly 700 New Jerseyans lost their lives. If a large passenger jet can bring down the World Trade Center, can the NRC really be sure that nuclear reactor containment systems would withstand such a direct, high-speed hit?

Response. After 9–11, the NRC conducted detailed site-specific security assessments at four selected sites. While those studies were underway, the NRC took direct regulatory action to enhance safety and security at nuclear power plants and spent fuel pools. In February 2002, the NRC ordered the nuclear power industry to develop and implement mitigation strategies based on a general understanding that terrorist activities could result in some level of structural or fire damage to a facility. Furthermore, the NRC also decided that additional site-specific inspections (of the items ordered in 2002) and site-specific studies of mitigation capabilities should be conducted at all sites, including all spent fuel pools, to further enhance protection capabilities. Guidance for those activities has been developed and pilot programs have been conducted. All site-specific spent fuel pool assessments are scheduled to be completed by November 30, 2005.

In conducting these studies, the NRC drew on national experts from several U.S. Department of Energy (DOE) laboratories using state-of-the-art structural and fire analyses. The agency also enhanced its ability to predict realistically accident progression due to the loss of large areas of reactor sites due to fires and explosions and any consequent releases of radiation to the environment. For the facilities analyzed, the studies confirm that the likelihood of both damaging the reactor core and releasing radioactivity from an aircraft crash event that could affect public health and safety is low.

RESPONSES BY NIL J. DIAZ TO ADDITIONAL QUESTIONS FROM SENATOR VOINOVICH

Question 1. NRC's testimony indicates that the Commission is taking action to address safety culture by identifying appropriate measures and developing guidance for licensees—leading up to the modification of the Reactor Oversight Process. Please go into greater detail for the Committee on what the Commission has discovered and what actions the NRC has and will take.

Response. In response to direction provided by the Commission in August 2004, the NRC staff is currently conducting activities to enhance the Reactor Oversight Process treatment of cross cutting issues to address safety culture more fully. These activities include new tools and training for the inspection staff. The staff's activities will take into account the ongoing industry initiatives and information from the international community.

One element of a safety culture is maintaining a safety conscious work environment. In October 2004, NRC issued a draft guidance document entitled, "Guidance for Establishing and Maintaining a Safety Conscious Work Environment" in the *Federal Register* for public comment. This guidance document was developed to pro-

vide supplementary guidance on fulfilling the expectation to ensure safe operation of facilities, in part, by establishing and maintaining a safety conscious work environment. It provides guidance on (1) encouraging employees to raise safety concerns, including recognition initiatives and communication tools, (2) Safety Conscious Work Environment training content, (3) alternative processes for addressing concerns, such as employee concerns and ombudsman programs, (4) tools to assess the Safety Conscious Work Environment, including performance indicators, behavioral observations, and surveys, (5) contractor awareness of Safety Conscious Work Environment principles and expectations, and (6) processes that help detect and prevent discrimination, and avoid the appearance of discrimination. NRC staff has been evaluating comments received on the draft document, and the final version of this guidance document is expected to be issued in August 2005.

The NRC staff continues to monitor closely the licensees' corrective actions associated with safety culture and Safety Conscious Work Environment issues at both the Davis-Besse Nuclear Plant and Salem/Hope Creek Nuclear Plants. In addition, the Institute of Nuclear Power Operations, a nuclear industry organization which routinely performs peer evaluations at member nuclear facilities, has agreed to having an NRC observer on its plant evaluation team. This will be supportive of the Commission direction to monitor industry efforts to assess safety culture.

The existing regulatory infrastructure provides a framework for monitoring the impact of licensee safety culture on performance. This includes the following items: (1) direct, daily observation of licensee operation of the facilities by Resident Inspectors at each site; (2) periodic inspections focusing on Problem Identification and Resolution at each site by Region-based inspection team; (3) followup of individual Allegations and trending for Safety Conscious Work Environment Assessments; (4) enforcement of employee protection regulations which prohibit adverse action against employees who raise safety concerns; (5) the Reactor Oversight Process—management evaluation of insights gained from inspections and allegations to determine regulatory action; (6) early and aggressive action where potential safety performance or safety culture issues are observed (e.g., Salem and Hope Creek); and (7) implementation of corrective actions, such as those included in the Davis-Besse Lessons Learned Task Force recommendations, to improve the assessment capability. These are in addition to our continuing oversight of safety management.

Question 2. In its 1998 report to Congress, the Commission concluded that the Price-Anderson Act has proven to be "remarkably successful" and is "prudent public policy." The report's specific recommendation was: "Because the Act has benefited from extensive public discussion and legislative modifications over the years, only modest changes, if any, need be contemplated in connection with its renewal." Does NRC still support the conclusion of your 1998 report to Congress that the Price-Anderson Act should be extended with only modest—or perhaps no—changes?

Response. Yes. As stated in our written testimony submitted for the May 26, 2005 hearing, the Commission supports the enactment of S. 865, extending the Price-Anderson Act as it applies to NRC authority to indemnify certain classes of licensees. The provisions of the Price-Anderson Act applicable to NRC's authority to indemnify expired on December 31, 2003, having previously been extended for only 1 year as an interim measure. Until the Act is renewed, the Commission lacks the authority to enter into new indemnity agreements with licensees for new facilities. Expiration of the Price-Anderson Act does not affect the currently licensed facilities since the indemnification agreements, which are required by the Act for certain facilities and implement the Act, remain in force for the life of the facility.

Question 3. NRC has requested increased funding. What steps has the Commission taken to save money?

Response. The NRC has long been committed to the goal of being effective and efficient. The Commission emphasized this commitment by making effectiveness and efficiency one of the five goals in its FY 2004–FY 2009 Strategic Plan, along with safety, security, openness, and management excellence. This commitment to efficiency is also reflected in the Commission's annual budget request for resources to conduct an effective regulatory program that enables the Nation to use nuclear energy and nuclear materials safely for civilian purposes. This budget is developed using the agency's Planning, Budgeting, and Performance Management (PBPM) process. This disciplined process, including the Commission review and decisions, ensures that only those programs that are effective in meeting the agency's mission and goals continue. Additionally, efficiencies which reduce program and support costs are identified and incorporated in the resource estimates. These efficiencies are highlighted by the following actions that have been taken to save money.

The Commission has modified its programs and processes to make them more efficient, effective, and predictable. This includes consolidating programs where it has

made sense to do so. For example, the Commission recently consolidated oversight responsibility for all major fuel cycle facilities in its Region II office. The Commission also recently consolidated responsibility for the inspection and licensing of materials users for two of its regions in its Region I office. The Reactor Oversight Process was implemented several years ago to streamline the inspection process by using a risk-informed approach. The Commission has made continuous improvement to its reactor license renewal process. This has resulted in reducing the time to review an application from 30 months to 22 months without a hearing, while realizing a reduction in the resources necessary for the review. More discipline has also been applied to managing the NRC's adjudicatory hearing process, which has made it more efficient. The Commission also leverages its resources by developing collaborative arrangements with industry, foreign governments, and international organizations to share the costs of research and other technical evaluations in areas such as material degradation, human factors, and fuel behavior.

The Commission has also taken actions to save operating costs. For example, the Commission has used available information technology to reduce the cost of its safety analysis by moving scientific computer codes from the relatively high cost mainframes at the DOE national laboratories to a much lower cost in-house computing environment. The Commission has been able to significantly reduce the operating and maintenance costs for agency financial systems by cross servicing such services with other Federal agencies. The Commission has recently reconfigured existing headquarter offices to avoid having to obtain additional space to accommodate its increased workload.

The above examples have all been implemented during over a period of increased workload and inflation. These examples demonstrate the Commission's recognition of the importance of being an efficient regulator. The Commission remains committed to maximizing the effectiveness, efficiency and predictability of its programs and supporting systems.

Question 4. NRC has proposed to move their Technical Training Center (TTC) in Chattanooga, Tennessee to a location near its headquarters in Rockville, Maryland. Please provide the cost-benefit analysis on moving this Center.

Response. The agency performed a cost-benefit analysis of moving the TTC to a location near Rockville, Maryland, in 1999. The study indicated that over a 10-year period the costs of operating the TTC in either Rockville or Chattanooga, including the cost of the move, would be roughly equal. The Commission continues to look for opportunities to enhance the efficiency and effectiveness of our technical training program for staff. A new study would be necessary to reflect the current environment (i.e., staffing increases, skill needs, space cost, etc.).

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Testimony

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NUCLEAR REGULATORY COMMISSION

Challenges Facing NRC in Effectively Carrying Out Its Mission

Statement of Jim Wells, Director
Natural Resources and Environment

GAO
Accountability * Integrity * Reliability

GAO-05-754T

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Highlights

Highlights of GAO-05-754T, a testimony before the Subcommittee on Clean Air, Climate Change, and Nuclear Safety, Committee on Environment and Public Works, U.S. Senate

NUCLEAR REGULATORY COMMISSION

Challenges Facing NRC in Effectively Carrying Out Its Mission

Why GAO Did This Study

The Nuclear Regulatory Commission (NRC) has the regulatory responsibility to, among other things, ensure that the nation's 103 commercial nuclear power plants are operated in a safe and secure manner. While the nuclear power industry's overall safety record has been good, safety issues periodically arise that threaten the credibility of NRC's regulation and oversight of the industry.

Recent events make the importance of NRC's regulatory and oversight responsibilities readily apparent. The terrorist attacks on September 11, 2001, focused attention on the security of facilities such as commercial nuclear power plants, while safety concerns were heightened by shutdown of the Davis-Besse nuclear power plant in Ohio in 2002, and the discovery of missing or unaccounted for spent nuclear fuel at three nuclear power plants.

GAO has issued a total of 15 recent reports and testimonies on a wide range of NRC activities. This testimony (1) summarizes GAO's findings and associated recommendations for improving NRC mission-related activities and (2) presents several cross-cutting challenges NRC faces in being an effective and credible regulator of the nuclear power industry.

www.gao.gov/cgi-bin/getrpt?GAO-05-754T.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells at (202) 512-3841 or wellsj@gao.gov.

What GAO Found

GAO has documented many positive steps taken by NRC to advance the security and safety of the nation's nuclear power plants. It has also identified various actions that NRC needs to take to better carry out its mission. First, with respect to its security mission, GAO found that NRC needs to improve security measures for sealed sources of radioactive materials — radioactive material encapsulated in stainless steel or other metal used in medicine, industry, and research–which could be used to make a "dirty bomb." GAO also found that, although NRC was taking numerous actions to require nuclear power plants to enhance security, NRC needed to strengthen its oversight of security at the plants. Second, with respect to its public health and safety, and environmental missions, GAO found that NRC needs to conduct more effective analyses of plant owners' funding for decommissioning to ensure that the significant volume of radioactive waste remaining after the permanent closure of a plant are properly disposed. Further, NRC needs to more aggressively and comprehensively resolve issues that led to the shutdown of the Davis-Besse nuclear power plant by improving its oversight of plant safety conditions. Finally, NRC needs to do more to ensure that power plants are effectively controlling spent nuclear fuel, including developing and implementing appropriate inspection procedures.

GAO has identified several cross-cutting challenges affecting NRC's ability to effectively and credibly regulate the nuclear power industry. Recently, NRC has taken two overarching approaches to its regulatory and oversight responsibilities. These approaches are to (1) develop and implement a risk-informed regulatory strategy that targets the most important safety-related activities and (2) strike a balance between verifying plants' compliance with requirements through inspections and affording licensees the opportunity to demonstrate that they are operating their plants safety. NRC must overcome significant obstacles to fully implement its risk-informed regulatory strategy across agency operations, especially with regards to developing the ability to identify emerging technical issues and adjust regulatory requirements before safety problems develop. NRC also faces inherent challenges in achieving the appropriate balance between more direct oversight and industry self-compliance. Incidents such as the 2002 shutdown of the Davis-Besse plant and the unaccounted for spent nuclear fuel at several plants raise questions about whether NRC has the risk information that it needs and whether it is appropriately balancing agency involvement and licensee self-monitoring. Finally, GAO believes that NRC will face challenges managing its resources while meeting increasing regulatory and oversight demands. NRC's resources have already been stretched by the extensive effort to enhance security at plants in the wake of the September 11, 2001, terrorist attacks. Pressure on NRC's resources will continue as the nation's fleet of plants age and the industry's interest in expansion grows, both in licensing and constructing new plants, and re-licensing and increasing the power output of existing ones.

Mr. Chairman and Members of the Subcommittee:

I am pleased to be here today to participate in the Subcommittee's oversight hearing on the Nuclear Regulatory Commission (NRC). NRC has the regulatory responsibility to ensure that the nation's 103 operating commercial nuclear power plants are operated in a safe and secure manner. These plants provide about 20 percent of the country's electricity, but safety of their operations is paramount, given the potentially devastating effects of a nuclear accident. While the nuclear power industry's overall safety record has been good, safety issues periodically arise that raise questions about NRC's regulation and oversight of the industry and challenge its credibility for guaranteeing the safety of the nation's aging fleet of nuclear power plants. NRC plays an important role in protecting public health and the environment through its regulation of the nuclear power industry and other civilian use of nuclear material, and we commend the Subcommittee for holding this hearing.

NRC was formed in 1975, to regulate the various commercial and institutional uses of nuclear energy, including nuclear power plants. NRC's mission is to regulate the nation's civilian use of nuclear material to ensure adequate protection of public health and safety, to promote the common defense and security, and to protect the environment. NRC's activities include, among other things, licensing nuclear reactors (including license transfers and operating experience evaluation), reviewing plant safety procedures, imposing enforcement sanctions for violations of NRC requirements, and participating in homeland security efforts (including threat assessment, emergency response, mitigating strategies, security inspections, and force-on-force exercises). NRC also has regulatory oversight for the decommissioning of nuclear reactors, including accumulating sufficient funds to carry out decommissioning, and for the interim storage of spent nuclear fuel—the used fuel periodically removed from reactors in nuclear power plants.

The importance of NRC's regulatory and oversight responsibilities is made readily apparent by recent events. The terrorist attacks on September 11, 2001, and the subsequent discovery of nuclear power plants on a list of possible terrorist targets have focused attention on the security of the nation's commercial nuclear power plants. Safety concerns were heightened by the discovery of a pineapple-sized cavity in the carbon steel reactor vessel head, and subsequent 2–year shutdown, of the Davis-Besse nuclear power plant in Ohio in 2002. Additional safety concerns were raised by the discovery of missing or unaccounted for spent nuclear fuel at three nuclear power plants. Further, the decommissioning of some of the nations' aging nuclear power plants raises the issue of whether NRC is ensuring that plant owners are accumulating sufficient funds for decommissioning plants in a way that best protects public health, safety, and the environment.

Over the past 2 years, we have issued a total of 15 reports and testimonies on a wide range of NRC activities. (These reports are listed in Appendix I). While our work has primarily focused on identifying ways that NRC can strengthen its regulation and oversight of the nuclear power industry, we have documented a number of productive steps NRC has taken to improve its mission-related activities. One example is the substantial effort that NRC has made in working with the industry to enhance security at nuclear power plants since the September 11, 2001, terrorist attacks. Another example is NRC's considerable effort to analyze what went wrong at the Davis-Besse plant in 2002, and to incorporate the lessons learned into its processes. Today, my testimony will briefly summarize our recently completed NRC work. Specifically, this testimony (1) summarizes GAO's findings and associated recommendations for improving NRC mission-related activities and (2) provides some observations on cross-cutting challenges that NRC faces in being an effective and credible regulator of the nuclear power industry.

This testimony is based on seven of our recently issued reports. The other eight reports either address issues for which NRC is not the primary Federal agency—such as radioactive waste disposal and nuclear nonproliferation—or concern internal NRC administrative matters—such as fee recovery and information technology management. We did not perform additional audit work in preparing this testimony. The work for our previously issued reports was conducted in accordance with generally accepted government auditing standards.

SUMMARY

While NRC has improved its operations in a number of ways in recent years, GAO believes that the agency needs to take a number of additional actions to better fulfill its mission of ensuring that the nation's nuclear power plants and other civilian users of nuclear material operate in a safe and secure manner. First, operations related to NRC's security mission need to be improved. Specifically, we found that NRC has not developed adequate security measures for sealed sources of radioactive

materials—radioactive material encapsulated in stainless steel or other metal used in medicine, industry, and research—which could be used to make a "dirty bomb." We also found that despite taking numerous actions to respond to the heightened risks of a terrorist attack, NRC's oversight of physical security at the nation's commercial nuclear power plants could be strengthened. Second, operations related to NRC's public health and safety, and environmental missions need to be improved. Specifically, we found that NRC's analyses of plant owners' contributions of funds for the decommissioning of nuclear power plants, and its processes for acting on reports that show insufficient funds, do not ensure that the significant radioactive waste hazards that exist following the permanent closure of a nuclear power plant will be properly addressed. Further, we found that the issues surrounding the shutdown of the Davis-Besse power plant reveal important weaknesses in NRC's oversight of the safety of nuclear power plant operations. Finally, we found that NRC has not taken adequate steps to ensure that power plants are effectively controlling spent nuclear fuel, including developing and implementing appropriate inspection procedures to verify plants' compliance with NRC requirements.

NRC faces several cross-cutting challenges in being an effective and credible regulator of the nuclear power industry. In response to the agency's limited resources and its desire to reduce the regulatory burden and cost on plants, NRC is taking two overarching approaches to meeting its regulatory and oversight responsibilities: (1) developing and implementing a risk-informed regulatory strategy that targets industry's most important safety-related or safety-significant activities, and (2) striking a balance between verifying plants' compliance with requirements through inspections and affording licensees the opportunity to demonstrate that they are operating their plants safely. We believe that NRC must overcome significant obstacles in implementing its risk-informed regulatory strategy across the agency, especially with regards to developing the ability to identify emerging technical issues and adjust regulatory requirements before safety problems develop. We also believe that NRC faces inherent challenges in balancing oversight and industry self-compliance, especially with regards to positioning the agency so it is able to identify diminishing performance at individual plants before they become a problem. Incidents such as the 2002 shutdown of the Davis-Besse plant and the unaccounted for spent nuclear fuel at several plants raise questions about whether NRC has the risk information that it needs and whether it is appropriately balancing agency involvement and licensee self-monitoring. Finally, we believe that NRC will face challenges managing its resources while meeting increasing regulatory and oversight demands. NRC's resources have already been stretched by the extensive effort to enhance security at plants in the wake of the September 11, 2001, terrorist attacks. Pressure on NRC's resources will continue as the nation's fleet of plants age and the industry's interest in expansion grows, both in licensing and constructing new plants, and re-licensing and increasing the power output of existing ones.

REGULATORY AND OVERSIGHT FUNCTIONS VITAL TO NRC'S MISSION NEED TO BE IMPROVED

Our recent analyses of NRC programs identified several areas where NRC needs to take action to better fulfill its mission and made associated recommendations for improvement. With respect to NRC's security mission, we found that the security of sealed radioactive sources and the physical security at nuclear power plants need to be strengthened. With respect to its public health and safety, and environmental missions, we found several shortcomings that need to be addressed. NRC's analyses of plant owners' contributions could be improved to better ensure that adequate funds are accumulating for the decommissioning of nuclear power plants. By contrast, we found that NRC is ensuring that requirements for liability insurance for nuclear power plants owned by limited liability companies are being met. Further, to ensure the safety of nuclear power plants NRC must more aggressively and comprehensively resolve oversight issues related to the shutdown of the Davis-Besse plant. Finally, NRC's methods of ensuring that power plants are effectively controlling spent nuclear fuel need to be improved.

Operations Related to NRC's Security Mission Could Be Improved

In August 2003, we reported on Federal and state actions needed to improve security of sealed radioactive sources.[1] Sealed radioactive sources, radioactive material encapsulated in stainless steel or other metal, are used worldwide in medicine, industry, and research. These sealed sources could be a threat to national security be-

[1] GAO: Nuclear Security Federal and State Action Needed to Improve Security of Sealed Radioactive Sources, GAO–03–804 Washington, D.C.: Aug. 6, 2003.

cause terrorists could use them to make “dirty bombs.” We were asked among other things to determine the number of sealed sources in the United States. We found that the number of sealed sources in use today in the United States is unknown primarily because no state or Federal agency tracks individual sealed sources. Instead, NRC and the agreement states[2] track numbers of specific licensees. NEC and the Department of Energy (DOE) have begun to examine options for developing a national tracking system, but to date, this effort has had limited involvement by the agreement states. NRC had difficulty locating owners of certain generally licensed devices it began tracking in April 2001, and has hired a private investigation firm to help locate them. Twenty-five of the 31 agreement states that responded to our survey indicated that they track some or all general licensees or generally licensed devices, and 17 were able to provide data on the number of generally licensed devices in their jurisdictions, totaling approximately 17,000 devices. GAO recommended that NRC (1) collaborate with states to determine the availability of the highest risk sealed sources, (2) determine if owners of certain devices should apply for licenses, (3) modify NRC’s licensing process so sealed sources cannot be purchased until NRC verifies their intended use, (4) ensure that NRC’s evaluation of Federal and state programs assesses the security of sealed sources, and (5) determine how states can participate in implementing additional security measures. NRC disagreed with some of our findings.

In September 2003, we reported that NRC’s oversight of security at commercial nuclear power plants needed to be strengthened.[3] The September 11, 2001, terrorist attacks intensified the nation’s focus on national preparedness and homeland security. Among possible terrorist targets are the nation’s nuclear power plants which contain radioactive fuel and waste. NRC oversees plant security through an inspection program designed to verify the plants’ compliance with security requirements. As part of that program, NRC conducted annual security inspections of plants and force-on-force exercises to test plant security against a simulated terrorist attack. GAO was asked to review (1) the effectiveness of NRC’s security inspection program and (2) legal challenges affecting power plant security. At the time of our review, NRC was reevaluating its inspection program. We did not assess the adequacy of security at the individual plants; rather, our focus was on NRC’s oversight and regulation of plant security.

We found that NRC had taken numerous actions to respond to the heightened risk of terrorist attack, including interacting with the Department of Homeland Security and issuing orders designed to increase security and improve defensive barriers at plants. However, three aspects of NRC’s security inspection program reduced the agency’s effectiveness in overseeing security at commercial nuclear power plants. First, NRC inspectors often used a process that minimized the significance of security problems found in annual inspections by classifying them as “non-cited violations” if the problem had not been identified frequently in the past or if the problem had no direct, immediate, adverse consequences at the time it was identified. Non-cited violations do not require a written response from the licensee and do not require NRC inspectors to verify that the problem has been corrected. For example, guards at one plant failed to physically search several individuals for metal objects after a walk-through detector and a hand-held scanner detected metal objects in their clothing. These individuals were then allowed unescorted access throughout the plant’s protected area. By extensively using non-cited violations for serious problems, NRC may overstate the level of security at a power plant and reduce the likelihood that needed improvements are made. Second, NRC did not have a routine, centralized process for collecting, analyzing, and disseminating security inspections data to identify problems that may be common to plants or to provide lessons learned in resolving security problems. Such a mechanism may help plants improve their security. Third, although NRC’s force-on-force exercises can demonstrate how well a nuclear plant might defend against a real-life threat, several weaknesses in how NRC conducted these exercises limited their usefulness. Weaknesses included (1) using more personnel to defend the plant during these exercises than during normal operations, (2) using attacking forces that are not trained in terrorist tactics, and (3) using unrealistic weapons (rubber guns) that do not simulate actual gunfire. Furthermore, at the time, NRC has made only limited use of some

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[2] Agreement states are the 33 states that have entered into an agreement with the NRC under subsection 274(b) of the Atomic Energy Act (AEA) under which NRC relinquishes to the states portions of its regulatory authority to license and regulate source, byproduct, and certain quantities of special nuclear material.

[3] GAO: Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to Be Strengthened, GAO–03–752 (Washington, D.C.: Sept. 4, 2003).

available improvements that would make force-on-force exercises more realistic and provide a more useful learning experience.

Finally, we also found that even if NRC strengthens its inspection program, commercial nuclear power plants face legal challenges in ensuring plant security. First, Federal law generally prohibits guards at these plants from using automatic weapons, although terrorists are likely to have them. As a result, guards at commercial nuclear power plants could be at a disadvantage in firepower, if attacked. Second, state laws regarding the permissible use of deadly force and the authority to arrest and detain intruders vary, and guards were unsure about the extent of their authorities and may hesitate or fail to act if the plant is attacked. GAO made recommendations to promptly restore annual security inspections and revise force-on-force exercises. NRC disagreed with many of GAO's findings, but did not comment on GAO's recommendations.

In September 2004, we testified on our preliminary observations regarding NBC's efforts to improve security at nuclear power plants.[4] The events of September 11, 2001, and the subsequent discovery of commercial nuclear power plants on a list of possible terrorist targets have focused considerable attention on plants' capabilities to defend against a terrorist attack. NRC is responsible for regulating and overseeing security at commercial nuclear power plants. We were asked to review (1) NRC's efforts since September 11, 2001, to improve security at nuclear power plants, including actions NRC had taken to implement some of GAO's September 2003 recommendations to improve security oversight, and (2) the extent to which NRC is in a position to assure itself and the public that the plants are protected against terrorist attacks. The testimony reflected the preliminary results of GAO's review. We are currently performing a more comprehensive review in which we are examining (1) NRC's development of its 2003 design basis threat (DBT), which establishes the maximum terrorist threat that commercial nuclear power plants must defend against, and (2) the security enhancements that plants have put in place in response to the design basis threat and related NRC requirements. We expect to issue a report on our findings later this year.

In the earlier work, we found that NRC responded quickly and decisively to the September 11, 2001, terrorist attacks with multiple steps to enhance security at commercial nuclear power plants. NRC immediately advised plants to go to the highest level of security using the system in place at the time, and issued advisories and orders for plants to make certain enhancements, such as installing more physical barriers and augmenting security forces, which could be quickly completed to shore up security. According to NRC officials, their inspections found that plants complied with these advisories and orders. Later, in April 2003, NRC issued a new DBT and required the plants to develop and implement new security plans to address the new threat by October 2004. NRC is also improving its force-on-force exercises, as GAO recommended in its September 2003 report. While its efforts had enhanced security, NRC was not yet in a position to provide an independent determination that each plant has taken reasonable and appropriate steps to protect against the new DBT. According to NRC officials, the facilities' new security plans were on schedule to be implemented by October 2004. However, NRC's review of the plans, which are not available to the general public for security reasons, had primarily been a paper review and was not detailed enough for NRC to determine if the plans would protect the facility against the threat presented in the DBT. In addition, NRC officials generally were not visiting the facilities to obtain site-specific information and assess the plans in terms of each facility's design. NRC is largely relying on the force-on-force exercises it conducts to test the plans, but these exercises will not be conducted at all facilities for 3 years. We also found that NRC did not plan to make some improvements in its inspection program that GAO previously recommended. For example, NRC was not following up to verify that all violations of security requirements had been corrected, nor was the agency taking steps to make "lessons learned" from inspections available to other NRC regional offices and nuclear power plants.

Operations Related to NRC's Public Health and Safety and Environmental Missions Can Be Improved

In October 2003, we reported that NRC needs to more effectively analyze whether nuclear power plant owners are adequately accumulating funds for decommissioning plants.[5] Following the closure of a nuclear power plant, a significant radioactive

[4] GAO, Nuclear Regulatory Commission: Preliminary Observations on Efforts to Improve Security at NuclearPower Plants, GAO–04–1064T (Washington, D.C.: Sept. 14, 2004).

[5] GAO: Nuclear Regulation: NRC Needs More Effective Analysis to Ensure Accumulation of Funds to Decommission Nuclear Power Plants, GAO–04–32 (Washington, D.C.: Oct. 30, 2003).

waste hazard remains until the waste is removed and the plant site is decommissioned. In 1988, NRC began requiring owners to (1) certify that sufficient financial resources would be available when needed to decommission their nuclear power plants and (2) require them to make specific financial provisions for decommissioning. In 1999, GAO reported that the combined value of the owners' decommissioning funds was insufficient to ensure enough funds would be available for decommissioning. GAO was asked to update its 1999 report, and to evaluate NRC's analysis of the owners' funds and the agency's process for acting on reports that show insufficient funds.

We found that although the collective status of the owners' decommissioning fund accounts has improved considerably since GAO's last report, some individual owners were not on track to accumulate sufficient funds for decommissioning. Based on our analysis and using the most likely economic assumptions, we concluded that the combined value of nuclear power plant owners' decommissioning fund accounts in 2000—about $26.9 billion—was about 47 percent greater than needed at that point to ensure that sufficient funds would be available to cover the approximately $33 billion in estimated decommissioning costs when the plants are permanently closed. This value contrasts with GAO's prior finding that 1997 account balances were collectively 3 percent below what was needed. However, overall industry results can be misleading. Because funds are generally not transferable from funds that have more than sufficient reserves to those with insufficient reserves, each individual owner must ensure that enough funds are available for decommissioning their particular plants. We found that 33 owners with ownership interests in a total of 42 plants had accumulated fewer funds than needed through 2000, to be on track to pay for eventual decommissioning. In addition, 20 owners with ownership interests in a total of 31 plants recently contributed less to their trust funds than we estimated they needed in order to put them on track to meet their decommissioning obligations.

NRC's analysis of the owners' 2001 biennial reports was not effective in identifying owners that might not be accumulating sufficient funds to cover their eventual decommissioning costs. In reviewing the 2001 reports, NRC reported that all owners appeared to be on track to have sufficient funds for decommissioning. In reaching this conclusion, NRC relied on the owners' future plans for fully funding their decommissioning obligations. However, based on the owners' actual recent contributions, and using a different method, GAO found that several owners could be at risk of not meeting their financial obligations for decommissioning when these plants stop operating. In addition, for plants with more than one owner, NRC did not separately assess the status of each co-owner's trust funds against each co-owner's contractual obligation to fund decommissioning. Instead, NRC assessed whether the combined value of the trust funds for the plant as a whole were reasonable. Such an assessment for determining whether owners are accumulating sufficient funds can produce misleading results because owners with more than sufficient funds can appear to balance out owners with less than sufficient funds, even though funds are generally not transferable among owners. Furthermore, we found that NRC had not established criteria for taking action when it determines that an owner is not accumulating sufficient decommissioning funds.

We recommended that NRC (1) develop an effective method for determining whether owners are accumulating decommissioning funds at sufficient rates and (2) establish criteria for taking action when it is determined that an owner is not accumulating sufficient funds. NRC disagreed with these recommendations, suggesting that its method is effective and that it is better to deal with unacceptable levels of financial assurance on a case-by-case basis. GAO continues to believe that limitations in NRC's method reduce its effectiveness and that, without criteria, NRC might not be able to ensure owners are accumulating decommissioning funds at sufficient rates.

In May 2004, we issued a report on NRC's liability insurance requirements for nuclear power plants owned by limited liability companies.[6] An accident at one the nation's commercial nuclear power plants could result in personal injury and property damage. To ensure that funds would be available to settle liability claims in such cases, the Price-Anderson Act requires licensees of these plants to have primary insurance—currently $300 million per site. The act also requires secondary coverage in the form of retrospective premiums to be contributed by all licensees of nuclear power plants to cover claims that exceed primary insurance. If these premiums are needed, each licensee's payments are limited to $10 million per year and $95.8 million in total for each of its plants. In recent years, limited liability compa-

[6] GAO, Nuclear Regulation: NRC's Liability Insurance Requirements for Nuclear Power Plants Owned by Limited Liability Companies, GAO–04–654 (Washington, D.C.: May 28, 2004).

nies have increasingly become licensees of nuclear power plants, raising concerns about whether these companies—which shield their parent corporations' assets—will have the financial resources to pay their retrospective premiums. We were asked to determine (1) the extent to which limited liability companies are the licensees for U.S. commercial nuclear power plants, (2) NRC's requirements and procedures for ensuring that licensees of nuclear power plants comply with the Price-Anderson Act's liability requirements, and (3) whether and how these procedures differ for licensees that are limited liability companies.

We found that of the 103 operating nuclear power plants, 31 were owned by 11 limited liability companies. Three energy corporations—Exelon, Entergy, and the Constellation Energy Group—were the parent companies for 8 of these limited liability companies. These 8 subsidiaries were the licensees or co-licensees for 27 of the 31 plants. We also found that NRC requires all licensees for nuclear power plants to show proof that they have the primary and secondary insurance coverage mandated by the Price-Anderson Act. Licensees sign an agreement with NRC that requires the licensee to keep the insurance in effect. American Nuclear Insurers also has a contractual agreement with each of the licensees that obligates the licensee to pay the retrospective premiums to American Nuclear Insurers if these payments become necessary. A certified copy of this agreement, which is called a bond for payment of retrospective premiums, is provided to NRC as proof of secondary insurance. Finally, we found that NRC does not treat limited liability companies differently than other licensees with respect to the Price-Anderson Act's insurance requirements. Like other licensees, limited liability companies must show proof of both primary and secondary insurance coverage. American Nuclear Insurers also requires limited liability companies to provide a letter of guarantee from their parent or other affiliated companies with sufficient assets to pay the retrospective premiums. These letters state that the parent or affiliated companies are responsible for paying the retrospective premiums if the limited liability company does not. American Nuclear Insurers informs NRC that it has received these letters.

In May 2004, we also issued a report documenting the need for NRC to more aggressively and comprehensively resolve issues related to the shutdown of the Davis-Besse nuclear power plant.[7] The most serious safety issue confronting the nation's commercial nuclear power industry since Three Mile Island in 1979, was identified at the Davis-Besse plant in Ohio in March of 2002. After NRC allowed Davis-Besse to delay shutting down to inspect its reactor vessel for cracked tubing, the plant found that leakage from these tubes had caused extensive corrosion on the vessel head—a vital barrier in preventing a radioactive release. GAO determined (1) why NRC did not identify and prevent the corrosion, (2) whether the process NRC used in deciding to delay the shutdown was credible, and (3) whether NRC is taking sufficient action in the wake of the incident to prevent similar problems from developing at other plants.

We found that NRC should have, but did not identify or prevent the corrosion at Davis-Besse because agency oversight did not produce accurate information on plant conditions. NRC inspectors were aware of indications of leaking tubes and corrosion; however, the inspectors did not recognize the importance of the indications and did not fully communicate information about them to other NRC staff. NRC also considered FirstEnergy—Davis-Besse's owner—a good performer, which resulted in fewer NRC inspections and questions about plant conditions. NRC was aware of the potential for cracked tubes and corrosion at plants like Davis-Besse but did not view them as an immediate concern. Thus, despite being aware of the development of potential problems, NRC did not modify its inspection activities to identify such conditions. Additionally, NRC's process for deciding to allow Davis-Besse to delay its shutdown lacked credibility. Because NRC had no guidance for making the specific decision of whether a plant should shut down, it instead used guidance for deciding whether a plant should be allowed to modify its operating license. However, NRC did not always follow this guidance and generally did not document how it applied the guidance. Furthermore, the risk estimate NRC used to help decide whether the plant should shut down was also flawed and underestimated the risk that Davis-Besse posed. Finally, even though it underestimated the risk posed by Davis-Besse, the risk estimate applied to the plant still exceeded levels generally accepted by the agency. Nevertheless, Davis-Besse was allowed to delay the plant's shutdown.

After this incident, NRC took several significant actions to help prevent reactor vessel corrosion from recurring at nuclear power plants. For example, NRC has required more extensive vessel examinations and augmented inspector training. I

[7] GAO, Nuclear Regulation: NRC Needs to More Aggressively and Comprehensively Resolve Issues Related to the Davis Besse Nuclear Power Plant's Shutdown, GAO–04–415 (Washington, D.C.: May 17,2004).

would also like to note that, in April 2005, NRC proposed a $5.45 million fine against the licensee of the Davis-Besse plant. The principal violation was that the utility restarted and operated the plant in May 2000, without fully characterizing and eliminating leakage from the reactor vessel head. Additional violations included providing incomplete and inaccurate information to NRC on the extent of cleaning and inspecting the reactor vessel head in 2000.

While NRC has not yet completed all of its planned actions, we remain concerned that NRC has no plans to address three systemic weaknesses underscored by the incident at Davis-Besse. Specifically, NRC has proposed no actions to help it better (1) identify early indications of deteriorating safety conditions at plants, (2) decide whether to shut down a plant, or (3) monitor actions taken in response to incidents at plants. Both NRC and GAO had previously identified problems in NRC programs that contributed to the Davis-Besse incident, yet these problems continued to persist. Because the nation's nuclear power plants are aging, GAO recommended that NRC take more aggressive actions to mitigate the risk of serious safety problems occurring at Davis-Besse and other nuclear power plants.

In April 2005, we issued a report outlining the need for NRC to do more to ensure that power plants are effectively controlling spent nuclear fuel.[8] Spent nuclear fuel—the used fuel periodically removed from reactors in nuclear power plants—is too inefficient to power a nuclear reaction, but is intensely radioactive and continues to generate heat for thousands of years. Potential health and safety implications make the control of spent nuclear fuel of great importance. The discovery, in 2004, that spent fuel rods were missing at the Vermont Yankee plant in Vermont generated public concern and questions about NRC's regulation and oversight of this material. GAO reviewed (1) plants' performance in controlling and accounting for their spent nuclear fuel, (2) the effectiveness of NRC's regulations and oversight of plants' performance, and (3) NRC's actions to respond to plants' problems controlling their spent fuel.

We found that nuclear power plants' performance in controlling and accounting for their spent fuel has been uneven. Most recently, three plants—Vermont Yankee and Humboldt Bay (California) in 2004, and Millstone (Connecticut) in 2000—have reported missing spent fuel. Earlier, several other plants also had missing or unaccounted for spent fuel rods or rod fragments. NRC regulations require plants to maintain accurate records of their spent nuclear fuel and to conduct a physical inventory of the material at least once a year. The regulations, however, do not specify how physical inventories are to be conducted. As a result, plants differ in the regulations' implementation. For example, physical inventories at plants varied from a comprehensive verification of the spent fuel to an office review of the records and paperwork for consistency. Additionally, NRC regulations do not specify how individual fuel rods or segments are to be tracked. As a result, plants employ various methods for storing and accounting for this material. Further, NRC stopped inspecting plants' material control and accounting programs in 1988. According to NRC officials, there was no indication that inspections of these programs were needed until the event at Millstone. At the time of our review, NRC was collecting information on plants' spent fuel programs to decide if it needs to revise its regulations and/or oversight. It had its inspectors collect basic information on all facilities' programs. It also contracted with the Department of Energy's Oak Ridge National Laboratory in Tennessee to review NRC's material control and accounting programs for nuclear material. NRC is planning to request information from plants and plans to visit over a dozen plants for more detailed inspection. The results of these efforts may not be completed until late 2005, over 5 years after the incident at Millstone that initiated NRC's efforts. However, we believed NRC has already collected considerable information indicating problems or weaknesses in plants' material control and accounting programs for spent fuel.

GAO recommended that NRC (1) establish specific requirements for the way plants control and account for loose rods and fragments as well as conduct their physical inventories, and (2) develop and implement appropriate inspection procedures to verify plants' compliance with the requirements.

NRC FACES SEVERAL BROAD CHALLENGES IN EFFECTIVELY REGULATING AND OVERSEEING NUCLEAR POWER PLANTS

Based on our recent work at NRC, we have identified several cross-cutting challenges that NRC faces as it works to effectively regulate and oversee the nuclear power industry. First, NRC must manage the implementation of its risk-informed

[8] GAO, Nuclear Regulatory Commission: NRC Needs to Do More to Ensure that Power Plants Are Effectively Controlling Spent Nuclear Fuel, GAO–05–339 (Washington, D.C.: Apr. 8, 2005).

regulatory strategy across the agency's operations. Second, and relatedly, NRC must strive to achieve the appropriate balance between more direct involvement in the operations of nuclear power plants and self-reliance and self-reporting on the part of plant operators to do the right things to ensure safety. Third, and finally, NRC must ensure that the agency effectively manages resources to implement its risk-informed strategy and achieve the appropriate regulatory balance in the current context of increasing regulatory and oversight demands as the industry's interest in expansion grows.

NRC Must Manage the Implementation of Its Risk-Informed Regulatory Strategy

Nuclear power plants have many physical structures, systems, and components, and licensees have numerous activities under way, 24 hours a day, to ensure that plants operate safely. NRC relies on, among other things, the agency's onsite resident inspectors to assess plant conditions and oversee quality assurance programs, such as maintenance and operations, established by operators to ensure safety at the plants. Monitoring, maintenance, and inspection programs are used to ensure quality assurance and safe operations. To carry out these programs, licensees typically prepare numerous reports describing conditions at plants that need to be addressed to ensure continued safe operations. Because of the significant number of activities and physical structures, systems, and components, NRC adopted a risk-informed strategy to focus inspections on those activities and pieces of equipment that are considered to be the most significant for protecting public health and safety. Under the risk-informed approach, some systems and activities that NRC considers to have relatively less safety significance receive little agency oversight. With its current resources, NRC can inspect only a relatively small sample of the numerous activities going on during complex plant operations. NRC has adopted a risk-informed approach because it believes that it can focus its regulatory resources on those areas of the plant that the agency considers the most important to safety. NRC has stated the adoption of this approach was made possible by the fact that safety performance at plants has improved as a result of more than 25 years of operating experience.

Nevertheless, we believe that NRC faces a significant challenge in effectively implementing its risk-informed strategy, especially with regards to improving the quality of its risk information and identifying emerging technical issues and adjusting regulatory requirements before safety problems develop. The 2002 shutdown of the Davis-Besse plant illustrates this challenge, notably the shortcomings in NRC's risk estimate and failure to sufficiently address the boric acid corrosion and nozzle cracking issues. We also note that NRC's Inspector General considers the development and implementation of a risk-informed regulatory oversight strategy to be one of the most serious management challenges facing NRC.

NRC Must Balance Oversight and Industry Self-Compliance

Under the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended, NRC and the operators of nuclear power plants share the responsibility for ensuring that nuclear reactors are operated safely. NRC is responsible for issuing regulations, licensing and inspecting plants, and requiring action, as necessary, to protect public health and safety. Plant operators have the primary responsibility for safely operating their plants in accordance with their licenses. NRC has the authority to take actions, up to and including shutting down a plant, if licensing conditions are not being met and the plant poses an undue risk to public health and safety.

NRC has sought to strike a balance between verifying plants' compliance with requirements through inspections and affording licensees the opportunity to demonstrate that they are operating their plants safely. While NRC oversees processes, such as the use of performance measures and indicators, and requirements that licensees maintain their own quality assurance programs, NRC, in effect, relies on licensees and trusts them to a large extent to make sure their plants are operated safely. While this approach has generally worked, we believe that NRC still has work to do to effectively position itself so that it can identify problems with diminishing performance at individual plants before they become serious. For example, incidents such as the 2002 discovery of the extensive reactor vessel head corrosion at the Davis-Besse plant and the unaccounted for spent nuclear fuel at several plants across the country, raise questions about whether NRC is appropriately balancing agency involvement and self-monitoring by licensees. An important aspect of NRC's ability to rely on licensees to maintain their own quality assurance programs is a mechanism to identify deteriorating performance at a plant before the plant becomes a problem. At Davis-Besse, NRC inspectors viewed the licensee as a good performer based on its past performance and did not ask the questions that should

have been asked about plant conditions. Consequently, the inspectors did not make sure that the licensee adequately investigated the indications of the problem and did not fully communicate the indications to the regional office and NRC headquarters.

NRC Must Manage Agency Resources to Meet Increasing Regulatory and Oversight Demands

Finally, Mr. Chairman, I would also like to comment briefly on NRC's resources. While we have not assessed the adequacy of NRC's resources, we have noted instances, such the shutdown of the Davis-Besse plant, where resource constraints affected the agency's oversight or delayed certain activities. NRC's resources have been challenged by the need to enhance security at nuclear power plants after the September 11, 2001, terrorist attacks, and they will continue to be challenged as the nation's fleet of nuclear power plants age and the industry's interest grows in both licensing and constructing newplants, and re-licensing and increasing the output of existing plants. Resource demands will also increase when the Department of Energy submits for NRC review, an application to construct and operate a national depository for high-level radioactive waste currently planned for Yucca Mountain, Nevada. We believe that it is important for NRC and the Congress to monitor agency resources as these demands arise in order to ensure that NRC can meet all of its regulatory and oversight responsibilities and fulfill its mission to ensure adequate protection of public health, safety, and the environment.

CONCLUSION

In closing, we recognize and appreciate the complexities of NRC's regulatory and oversight efforts required to ensure the safe and secure operation of the nation's commercial nuclear power plants. As GAO's recent work has demonstrated, NRC does a lot right but it still has important work to do. Whether NRC carries out its regulatory and oversight responsibilities in an effective and credible manner will have a significant impact on the future direction of our nation's use of nuclear power.

Finally, we note that NRC has generally been responsive to our report findings. Although the agency does not always agree with our specific recommendations, it has continued to work to improve in the areas we have identified. It has implemented many of our recommendations and is working on others. For example, with respect to nuclear power plant security, NRC has restored its security inspection program and resumed its forceon-force exercises with a much higher level of intensity. It is also strengthening these exercises by conducting them at individual plants every 3 years rather than every 8 years, and is using laser equipment to reduce the exercises' artificiality. Another example involves sealed radioactive sources. NRC is working with agreement states to develop a process for ensuring that high-risk radioactive sources cannot be obtained before verification that the materials will be used as intended. NRC anticipates that an NRC-agreement state working group will deliver a recommended approach to NRC senior management later this year. In addition, NRC continues to work on its broader challenges. For example, the agency intends to develop additional regulatory guidance to expand the application of risk-informed decisionmaking, including addressing the need to establish quality requirements for risk information and specific instructions for documenting the decision-making process and its conclusions.

We will continue to track NRC's progress in implementing our recommendations. In addition, as members of this subcommittee are aware, GAO has been asked to review the effectiveness of NRC's activities for overseeing nuclear power plants, that is, its reactor oversight process. An important part of that work would be to review the agency's risk-informed regulatory strategy and its effectiveness in identifying deteriorating plant performance as well as whether NRC is making progress toward effectively balancing agency inspections and self-monitoring by licensees.

Mr. Chairman, this completes my prepared statement. I would be pleased to respond to any questions that you or other Members of the subcommittee may have.

GAO CONTACTS AND STAFF ACKNOWLEDGEMENTS

For further information about this testimony, please contact me at (202) 512–3841 (or at *wellsj@gao.gov*). John W. Delicath, Ilene Pollack, and Raymond H. Smith, Jr. made key contributions to this testimony.

APPENDIX I

Related GAO Products

Nuclear Waste: Preliminary Observations on the QualityAssurance Program at the Yucca Mountain Repository. GAO–03–826T. Washington, D.C.: May 28, 2003.

Nuclear Regulatory Commission: Revision of Fee Schedules; Fee Recovery for fiscal year 2003 GAO–03–934R. Washington, D.C.: June 30, 2003.

Spent Nuclear Fuel: Options Exist to Further Enhance Security. GAO–03–426. Washington, D.C.: July 15, 2003.

Nuclear Security: Federal and State Action Needed to Improve Security of Sealed Radioactive Sources. GAO–03–804. Washington, D.C.: August 6, 2003.

Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to Be Strengthened GAO–03–752. Washington, D.C.: September 4, 2003.

Nuclear Regulation: NRC Needs More Effective Analysis to Ensure Accumulation of Funds to Decommission Nuclear Power Plants GAO–04–32. Washington, D.C.: October 30, 2003.

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Low-Level Radioactive Waste: Future Waste Volumes and Disposal Options Are Uncertain. GAO–04–1097T. Washington, D.C.: September 30, 2004.

Nuclear Regulatory Commission: NRC Needs to Do More to Ensure that Power Plants Are Effectively Controlling Spent Nuclear Fuel GAO–05–339. Washington, D.C.: April 8, 2005.

RESPONSE BY JIM WELLS TO ADDITIONAL QUESTION FROM SENATOR LAUTENBERG

Question. You raise questions about whether the NRC adequately balances oversight with the industry's self-monitoring. In today's increasingly competitive electricity markets would you agree that industry executives might feel compelled to place profits over consumer safety? Could this be one reason that needed plant shutdowns are sometimes delayed?

Response. No doubt nuclear power plants must sell the electricity they generate in markets that are increasingly competitive, and keeping costs down is an important aspect of being successful in these markets. During plant shutdown, costs are incurred but no electricity is being generated, which only adds to the costs that need to be recovered from electricity sales when the plant is operating. These costs include the cost of purchasing likely more-expensive electricity from other sources to meet a plant's electricity commitments to customers during shutdown. Thus, a decision to shut down a plant can have substantial financial impacts. During our review of the issues surrounding the 2002 shutdown of the Davis-Besse plant in Ohio, we heard some concerns expressed that plant performance had deteriorated as plant management tried to keep expenses down and that financial considerations may have played too large a role in some of the decisions that plant management made. However, our review of the Davis-Besse incident focused on NRC's oversight, and we found no evidence that the owner placed profits over safety.

STATEMENT OF MARILYN C. KRAY, VICE PRESIDENT, EXELON NUCLEAR AND PRESIDENT, NUSTART ENERGY DEVELOPMENT

Chairman Voinovich, Senator Carper, Members of the Subcommittee:

Thank you for the opportunity to appear before you today to discuss NuStart Energy Development's activities. I am Marilyn Kray, Vice President of Project Development for Exelon Nuclear and President of NuStart Energy Development.

NuStart is a consortium of nine U.S. power companies and two reactor vendors[1] that was formed last year with two purposes: first, to demonstrate the Nuclear Regulatory Commission's never-before-used licensing process to obtain a combined Construction and Operating License (COL) for an advanced nuclear power plant; and second, to complete the design engineering for two advanced reactor technologies, General Electric's Economic Simplified Boiling Water Reactor (ESBWR) and Westinghouse's Advanced Passive AP–1000. NuStart activities are being funded by the Department of Energy on a 50/50 cost sharing arrangement under the Nuclear Power 2010 Program.

Demonstrating the NRC licensing process and completing the engineering for new reactor designs are critical first steps toward the construction of a new generation of reactors in the United States, and the NRC will play a central role in both efforts.

NuStart plans to submit two COL applications to the NRC in 2008, and we anticipate that the Commission will complete its review of the applications by 2011. COL approval would allow a company or consortium of companies to begin construction of a new reactor with the hope of having a plant begin operation by 2015.

In general, the nuclear industry has identified seven preconditions to the construction of new nuclear plants. In addition to the NuStart objectives of demonstrating the regulatory process and completing reactor designs for passive technologies, these include:

- A demonstrated need for new base load power
- Confidence in a long-term solution for used fuel disposal
- Public confidence in nuclear power
- A sound nuclear power infrastructure
- Acceptable financial returns

I would like to touch briefly on each of these issues and to discuss the important role that the NRC and this Committee play in many of these areas.

DEMONSTRATION OF REGULATORY PROCESS

As noted above, one of NuStart's primary objectives is to demonstrate the Nuclear Regulatory Commission's never-before-used licensing process to obtain a combined Construction and Operating License (COL) for an advanced nuclear power plant.

Obtaining a COL is a critical step in a potential renaissance of the nuclear power industry in the United States. By achieving this, NuStart hopes to demonstrate that the COL can be obtained on schedule and within budget, and that advanced plant designs can be approved. Further, NuStart's efforts will provide a realistic time and cost estimate for building and operating a new nuclear plant in today's environment.

During the 1980s, nuclear plants were plagued with significant cost overruns due in large part to the regulatory uncertainty inherent in the NRC licensing process. Many major issues were argued and litigated only after plants had been constructed, in some cases delaying plant operations for years.

Congress took an important step to reform the licensing process as part of the Energy Policy Act of 1992 with the codification of the NRC's combined Construction and Operating License regulations under 10 CFR Part 52. The COL process is designed to provide all parties with an opportunity to raise issues related to siting and plant design before a license is granted. Once a plant is built, the only question before the Commission is whether the licensee has constructed the plant in conformance with its license. On paper the process appears to be sound; however, investor confidence will not be established until the process is demonstrated, as proposed under the NuStart project.

The new licensing process also gives potential licensees an opportunity to have sites pre-approved by the Commission. The Early Site Permit (ESP) process allows a potential licensee to apply to the Commission for approval of a site for a new nuclear plant. Companies provide the NRC with extensive data on the proposed site, as well as information about the reactor design that could be built on the site. If a site is approved, a company can "bank" the site for as long as 20 years.

[1] Power companies include: Constellation Energy, Duke Energy, EDF International North America, Entergy Nuclear, Exelon Generation, Florida Power and Light, Progress Energy, Southern Company and Tennessee Valley Authority. Reactor vendors include General Electric and Westinghouse.

Also under the Department of Energy's Nuclear Power 2010 program, three companies have received matching funds to develop and submit Early Site Permit applications to the NRC: Dominion's North Anna site in Virginia, Entergy's Grand Gulf site in Mississippi, and Exelon's Clinton Power Station in Illinois. All three applications are currently under review by the NRC, and we expect the Commission to issue the resultant permits starting in second half of 2006.

Other issues related to a stable regulatory environment include NRC management and security regulations for licensees.

The Commission's Regulatory Oversight Process, which seeks to focus NRC activities on those issues which carry the highest level of safety significance, has provided objective, measurable, safety-significant performance indicators that can be used as a basis for the assessment of licensee performance.

S. 864, the Nuclear Safety and Security Act, makes important reforms to the Atomic Energy Act to grant the NRC additional authority related to plant safety and security. The bill authorizes the use of firearms by security personnel and requires fingerprinting and criminal background checks for key personnel.

What remains, however, is the identification of any additional security requirements that may be imposed on new plants. Incorporation of these further enhancements into the ongoing design development will be easier the earlier they are identified.

COMPLETION OF REACTOR DESIGNS FOR PASSIVE TECHNOLOGIES

Another aspect of the revised NRC licensing regulations allows reactor vendors to submit designs to the NRC for Design Certification. This process allows the NRC to evaluate potential designs and allows for public participation in the certification process. Once a design is certified by the Commission, it can be paired with an Early Site Permit and used in the submission of a Construction and Operating License.

NuStart plans to complete the design engineering for two advanced reactor technologies, General Electric's ESBWR and Westinghouse's AP–1000. NuStart selected these technologies because they represent the optimization of operational confidence and innovation. They are natural evolutions of the designs currently in operation, yet both of these technologies adopt simplified design features and technology improvements that rely on inherent, passive safety systems. In this context, "passive" refers to design principles wherein laws of nature such as gravity feed, convective heat transfer and natural circulation are used in place of complex systems comprised of numerous pumps, valves and actuation devices. The result is an enhancement to safety because there is less reliance on equipment performance and operator action, and a reduction in cost because there is less equipment to construct and maintain.

NuStart's work with the reactor vendors to complete the one-time generic engineering work necessary for the standardized plant designs will position these technologies for deployment when needed, thereby significantly reducing the time to market for a new nuclear plant.

We are working closely with the Commission to assure that adequate staff resources will be in place to review the designs in a thorough and timely manner.

NEED FOR BASE LOAD POWER

Before any company commits to new generation, there must be confidence that there will be a need for new base load power. In some regions of the country, new base load power will be needed in the near future; in others, however, electric capacity is estimated to be sufficient to meet demand for the next 10 years or more. The market, not the energy industry nor the Federal Government, will dictate when new base load power is needed.

A LONG-TERM SOLUTION FOR USED FUEL DISPOSAL

While nuclear energy has a proven track record in the United States as a clean, economic and reliable source of energy, used fuel from nuclear plants must be managed to permanently isolate it from the environment.

Before new plants can be built, energy companies, investors and the public must be confident that there is a long-term solution for the disposal of used nuclear fuel. While individual companies may have different views on what constitutes an acceptable solution, it is essential that the Federal Government continue to make progress on meeting its statutory and contractual obligation to begin removing used fuel from reactor sites.

In 1982, the Federal Government codified its obligation to assure for the permanent disposal of high-level radioactive waste and used nuclear fuel. In 2002, Con-

gress upheld President George W. Bush's designation of Yucca Mountain, Nevada, as the site for the nation's permanent, deep geologic repository. While the Yucca Mountain project faces a number of challenges, the industry is confident that it will prove to be a scientifically suitable site for the permanent disposal of nuclear material.

The NRC will play a critical role in reviewing the license application for the proposed repository, and it is essential that the Commission have the resources necessary to complete its review.

PUBLIC CONFIDENCE IN NUCLEAR POWER

New nuclear power plants cannot be built without a high degree of public confidence in the safety of the technology, the competence and commitment of reactor operators, and the dedication of regulators. The industry recognizes that public confidence is based on the performance of our current fleet of plants. We must remain ever vigilant to the safety responsibility entrusted to us.

Public awareness of nuclear energy's positive contribution to energy independence, clean air, and a reliable, low-cost energy supply, has led to greater support in recent years. The nuclear industry's commitment to safe operations and its proven track record over the last 25 years have also reinforced public support for nuclear technology. In fact, recent surveys conducted on behalf of the Nuclear Energy Institute indicates that support for nuclear energy is at an all-time high, with 67 percent of Americans favoring the use of nuclear energy.

Public confidence in nuclear energy is also reinforced by the Price-Anderson Act, which assures that the public will be compensated quickly in the unlikely event of a nuclear incident. The Price-Anderson Act serves as a no-fault insurance policy, similar to that approved by Congress in the aftermath of the 9/11 attacks. Under Price-Anderson, the nuclear industry provides over $9 billion in coverage for a nuclear incident. Should claims exceed that amount, Congress is authorized to provide for additional compensation, including additional contributions from reactor owners. It is important to note that no taxpayer funds have been paid as a result of the Price-Anderson Act.

Both the Department of Energy and the Nuclear Regulatory Commission support Price-Anderson extension. While S. 865, the Price-Anderson Amendments Act of 2005, calls for a 20-year extension of the Act, the nuclear industry strong supports an indefinite extension of the Act.

The formation of NuStart resulted in significant public attention and led community leaders in Port Gibson, Mississippi; Oswego, New York; and Aiken, South Carolina to contact the consortium to express interest in having a new plant built in their area.

Last week, NuStart reached a major milestone with the announcement of six candidate sites for new reactors. These sites will be evaluated over the next several months, and two sites will be chosen for inclusion in NuStart's COL applications. The sites named last week are:

- Bellefonte Nuclear Plant, Hollywood, Alabama, owned by the Tennessee Valley Authority
- Grand Gulf Nuclear Station, Port Gibson, Mississippi, owned by Entergy Nuclear
- River Bend Nuclear Station, St. Francisville, Louisiana, also owned by Entergy
- Savannah River Site, a Department of Energy facility near Aiken, South Carolina
- Calvert Cliffs Nuclear Power Plant, Lusby, Maryland, owned by Constellation Energy
- Nine Mile Point Nuclear Station in Scriba, New York, owned by Constellation Energy

NUCLEAR POWER INFRASTRUCTURE

A critical challenge for the nuclear industry is the continued presence of a strong nuclear power infrastructure. This infrastructure includes the engineering expertise to design, construct, and operate plants; the existence of a strong educational network at the nation's colleges and universities; and the presence of knowledgeable and dedicated personnel to staff the Nuclear Regulatory Commission.

The lull in the construction of new nuclear power plants in the 1990s led to a decrease in the number of nuclear engineering students in American universities. As with many other businesses, the nuclear industry faces an aging workforce. If the commercial nuclear power industry in the United States is to expand, it is imperative that the Nation has a skilled workforce that is ready to construct, operate, and support new plants.

S. 858, the Nuclear Fees Reauthorization Act, includes provisions to addresses the human capital issue by authorizing the Commission to support institutions of higher learning to support courses related to nuclear safety, security or environmental protection; establishing an NRC scholarship and fellowship program; and authorizing the Commission to establish a partnership program with institutions of higher learning to promote education and research in relevant fields of study.

ACCEPTABLE FINANCIAL RETURNS

As a final prerequisite for new plant construction, companies will have to be confident that they can provide their shareholders with an acceptable financial return on their investment. Any investment in nuclear power must look attractive not only on an absolute basis, but superior to other fuel alternatives.

While the industry is optimistic that nuclear generation can be competitive to the other alternatives, it does expect that the "first mover" investors will face significant hurdles unique to a nuclear investment. Accordingly, financial incentives to stimulate construction of new nuclear plants will be needed. These incentives should address factors such as the licensing risk, investments risks and the issues that make it difficult for companies to undertake capital-intensive projects (i.e. earnings dilution during construction and long period for recovery of capital investment under existing tax depreciation rules). Such a cooperative industry /government financing program for the first plants is a necessary and appropriate investment in U.S. energy security.

CONCLUSION

Nuclear power is a critical component to our nation's overall energy portfolio and our pursuit of energy independence. Our interest in nuclear power is not to the exclusion of other energy sources. To date, nuclear power has managed to uphold its 20 percent contribution level despite the growing demand. This was possible because of the improvement opportunities to uprate the units and improve capacity factor. These opportunities are close to being exhausted. As a result, the percentage contribution level of nuclear will begin to decrease absent the construction of new plants.

One of the foundations of the nuclear industry is the commitment to planning. Although there is no immediate need for base load power, we recognize that action is needed now in order to preserve the nuclear option for the future. By identifying the preconditions for new plants we are able to develop action plans to address them. NuStart was formed to serve as the unified industry mechanism for addressing certain of these preconditions.

Thank you for the opportunity to appear before you today.

RESPONSES BY MARILYN C. KRAY TO ADDITIONAL QUESTIONS FROM SENATROR INHOFE

Question 1. With the announcement of the sites this week, you have reached an important milestone, what are the next milestones and timelines for NuStart—in other words, what is the next announcement that we should anticipate and when do you expect that to occur? What obstacles must (be) cleared to achieve that next milestone?

Response. The announcement of the six finalist sites was a significant milestone for the NuStart project. This announcement was the result of establishing a methodical approach for identifying candidate sites and performing initial evaluations. For the remainder of the calendar year, the NuStart milestones are as follows:

Third Quarter, 2005: Submittal of the General Electric Design Certification application to the NRC for the Economic Simplified Boiling Water Reactor (ESBWR)

October 1, 2005: Selection the two sites for the Combined Operating License (COL) applications

December 31, 2005: Westinghouse receipt of Design Certification from the NRC for the Advanced Passive (AP) 1000

With a Cooperative Agreement in place between NuStart Energy Development and the Department of Energy under the Nuclear Power 2010 Program, NuStart is well positioned to meet these near-term project milestones. For the remainder of the NuStart project, however, the ability of NuStart to meet its intended milestones is contingent upon continued funding of the Nuclear Power 2010 Program. These future milestones include the submittal of the two COL applications to the NRC and the NRC's subsequent review and approval. For 2006, we estimate that $74M is needed to fund the NuStart project as well as other Nuclear Power 2010 programs.

The $74M estimate is $18M above that suggested in the DOE 2006 budget. This increase is primarily a result of a proposed revision to the NuStart project to enable two sites to be selected and a separate COL application prepared and submitted for each. Additionally, NuStart has worked with each reactor vendor to accelerate the schedule for submittal of the COLS to the NRC. Both of these changes were made in response to interactions with the Department of Energy and the President's call for more new nuclear power plants.

Question 2. We often hear the argument that Price-Anderson was necessary 50 years ago to help an industry that had yet to be established, and that now that we have a mature nuclear industry, Price-Anderson is no longer necessary. Is Price-Anderson necessary for new nuclear units?

Response. Yes. Renewing the Act is an important step for new nuclear plant construction and for the public. The need for the provisions afforded by Price-Anderson is not necessarily linked to the maturity of the industry. The Price-Anderson Act provides prompt compensation to any persons harmed by a severe accident at a nuclear power plant in the U.S., even though the probability of such an accident is extremely remote. The law has served as a model for legislation in other areas ranging from vaccine compensation and medical malpractice to chemical waste cleanup.

The act provides substantial protection to the American public and eliminates any litigation regarding fault in the event of a severe accident at a nuclear power plant, which the U.S. Nuclear Regulatory Commission determines to be an "extraordinary nuclear occurrence." No other industry or insurance mechanism provides this degree of protection, up to $10 billion.

The costs of the Price-Anderson protection, like all the costs of nuclear-generated electricity, are borne by the industry, unlike the corresponding costs of some major power alternatives. Risks from hydropower (dam failure and resultant flooding), for example, are borne directly by the public. The 1977 failure of the Teton Dam in Idaho caused $500 million in property damage and the only compensation for individuals and businesses damaged by this event was about $200 million in low-cost government loans.

RESPONSES BY MARILYN C. KRAY TO ADDITIONAL QUESTIONS FROM SENATOR VOINOVICH

Question 1. How well do you think the NRC is prepared to handle the several important licensing issues—re-licensing for existing plants, potential applications to build new facilities, and Yucca Mountain—that are all occurring at the same time?

Response. The NRC is facing a resource challenge similar to that of the rest of the nuclear industry. According to a Nuclear Energy Institute (NEI) staffing survey published in 2004, nuclear power generation companies may lose an estimated 16,000 workers over the next 5 years, representing 28 percent of all jobs in the sector. The survey further found that nearly half of industry employees are over 47 years old, and less than 7 percent of employees are younger than 32 years old. This imbalance suggests a potentially inadequate supply of trained employees to replace departing personnel.

The industry has a major workforce activity for ensuring that qualified personnel will be available to support extended operating lifetimes for existing plants and new plant design, construction and operations. While this challenge is far from being resolved, specific interactions and partnerships are being established with labor organizations, universities, community colleges, high schools and middle schools to increase interest in the nuclear industry and associated engineering technologies.

We recognize that the NRC challenge is amplified by the need to staff for concurrent activities associated with new plants, the Yucca Mountain repository and relicensing of existing plants. To date, the NRC has reviewed and approved approximately 30 license renewal applications. The process for re-licensing has evolved into one that is both stable and consistent.

Similar NRC readiness will be needed to address the new plant activities. NRC management has expressed doubts on being able to manage more than three new plant licensing reviews at a given time: for example, a Design Certification review plus a Combined Operating License (COL) application review plus an Early Site Permit review, or a review of three parallel COL applications. This emerging NRC resource issue could become a barrier to new plant deployment, a critical element in the President and Congress's energy initiatives.

In the last 9 months, as the pace of industry-NRC interactions has increased, the resource estimates for NRC new plant licensing review activities has grown more uncertain. The NRC resource estimate for the review of a COL application, which references an Early Site Permit and a Design Certification has risen from 33 Full-

Time-Equivalents (FTEs) to over 60 FTEs, with a corresponding increase in estimated contractor costs. This uncertainty increases generating company anxiety over the new licensing process.

To ease the new plant licensing resource burden, we encourage the NRC to incorporate lessons learned from the Design Certifications and Early Site Permit demonstration projects into the licensing process, emulating the successful improvements in license renewal review efficiencies.

NuStart recognizes the role that the industry plays as potential applicants for these upcoming licensing actions. That is, we will continue to advise the NRC of our plans well in advance so as to allow the agency ample time to prepare.

Question 2. While S. 865, the Price-Anderson Act of 2005, reauthorizes the program for 20 years, you have asked for an indefinite extension. What are the advantages of a longer—or indefinite—extension?

Response. The Price-Anderson Act provides substantial benefit in its comprehensive protection to the American public.

Nuclear power plants provide up to a total of $10 billion in insurance coverage to compensate the public in the event of an extremely unlikely severe nuclear accident and the Federal Government pays nothing for this basic coverage. The act provides substantial protection to the American public and eliminates any litigation regarding fault in the event of a severe accident at a nuclear power plant, which the U.S. Nuclear Regulatory Commission determines to be an “extraordinary nuclear occurrence.” No other industry or insurance mechanism provides this degree of protection, up to $10 billion.

The costs of the Price-Anderson protection, like all the costs of nuclear-generated electricity, are borne by the industry, unlike the corresponding costs of some major power alternatives. Risks from hydropower (dam failure and resultant flooding), for example, are borne directly by the public. The 1977 failure of the Teton Dam in Idaho caused $500 million in property damage and the only compensation for individuals and businesses damaged by this event was about $200 million in low-cost government loans.

The periodic renewal of Price-Anderson casts doubt and uncertainty on whether the coverage will be available in the future and that could impact the long-term planning strategies and decisionmaking process of U.S. generating companies. In addition, continued periodic renewal of Price-Anderson unnecessarily increases the Congressional workload and staffing burden, when an indefinite or 50-year renewal can be justified based on the benefit provided to the American public.

Statement of Dr. Edwin S. Lyman, Senior Scientist, Global Security Program, Union of Concerned Scientists

Mr. Chairman and members of the Subcommittee, on behalf of the Union of Concerned Scientists, I would like to thank you for the opportunity to present our views on the effectiveness of the Nuclear Regulatory Commission (NRC) in overseeing the security and safety of nuclear power plants in the United States.

My name is Edwin Lyman. I have been a Senior Scientist with the Global Security Program at the Union of Concerned Scientists (UCS) since May 2003, focusing on ways to prevent nuclear proliferation, nuclear terrorism and radiological terrorism. I have been working on these issues for 14 years. Prior to my current position, I was with the Nuclear Control Institute for 7 years, and served as its president from 2002–2003. I received a PhD in physics from Cornell University in 1992, after which I did 3 years of postdoctoral work at Princeton, analyzing issues at the intersection of nuclear nonproliferation, nuclear safety and environmental protection.

I am testifying today as a public interest advocate in an unusual position. As the resultof my participation in an NRC hearing on security issues at a nuclear power plant in South Carolina, I have had access both to site-specific security information and to general information pertaining to the NRC’s post-9/11 security policies. I cannot discuss that information here in open session, although I would welcome the opportunity to do so at some future time in a closed forum. However, I am able to say that my long-standing concerns about security at NRC-regulated facilities have by no means been alleviated by what I have learned.

As I will discuss, UCS has two basic concerns about security at U.S. nuclear facilities in the post-9/11 world. First, some of these facilities possess highly enriched uranium or plutonium, which can be used to make nuclear weapons, and this material is potentially vulnerable to theft by terrorists. Second, nuclear power plants remain vulnerable to terrorist attacks that could result in the release of significant radiation—far more deadly than any “dirty bomb.”

What I find most troubling is that I see little evidence of “outside-the-box” thinking going on in the NRC or in the industry in response to emerging threats or safety concerns. They do not want to question the assumptions they have made because they are afraid of the answers they might get, especially if those answers end up costing the industry more money. But I doubt that America’s adversaries put similar constraints on themselves when plotting attacks.

The NRC has become too self-satisfied with the way it does business, too evasive about potential hazards, too unresponsive to external criticism, and too close to the industry that it regulates. Stringent oversight of the NRC by Congress and independent non-governmental groups is essential to counterbalance the lax regulation and enforcement that can result from complacency and to ensure that the NRC can effectively protect public health and safety. Congressional action in the security area is especially important, because the American public cannot directly participate in the discussion and has little other recourse for ensuring that the government is doing everything it can to protect it from nuclear and radiological terrorism. To this end, legislation is needed to ensure that there is independent review of NRC policy decisions pertaining to the protection of America’s commercial nuclear facilities against both radiological sabotage’ and theft of weapon-usable materials.

THEFT OF WEAPON-USABLE MATERIALS

Only a relatively small number of NRC-licensed facilities possess significant quantities of highly enriched uranium or plutonium, which if stolen could be used to make nuclear explosive devices. These include a couple of fuel fabrication plants and a number of research reactors. But the NRC’s responsibilities for regulation of the protection of nuclear materials against theft are growing in two key respects.

First, in the post-9/11 world there is greater concern about the potential for theft of weapon-usable fissile materials, in light of revelations that al Qaeda and other terrorist groups are intent on acquiring nuclear weapons. This calls into question, for example, the relatively lax security requirements that the NRC imposes on university research reactors that possess substantial quantities of highly enriched uranium.

Second, the number of NRC-licensed facilities that possess significant quantities of plutonium will increase if there is further action in the U.S. Department of Energy’s troubled program to dispose of excess weapon-grade plutonium by converting it to mixed-oxide fuel (MOX) and irradiating it in commercial reactors. Only last month, Duke Energy’s Catawba plant in South Carolina became the first U.S. nuclear power plant in decades to qualify as a “Category I” plutonium facility by virtue of its receipt of 80 kilograms of plutonium contained in four MOX lead test assemblies—enough to make a dozen Nagasaki-type nuclear bombs. If the test is successful, at least one other site, Duke’s McGuire plant in North Carolina, will take part in the program, and much larger quantities of plutonium-bearing MOX fuel will be shipped to both sites for years.

The NRC’s approach to ensuring the security of materials at these facilities against theft should be evolving to keep pace with the growing threat, but in our judgment, it is not. Instead, the NRC is weakening the standards. This is a problem because, at the same time, the U.S. is trying to teach Russia to better protect its own weapon-usable material. We would urge the Congress to take a closer look at these issues.

TERRORIST ATTACKS ON NUCLEAR POWER PLANTS AND THEIR CONSEQUENCES

More than 3 years after the 9/11 attacks, UCS continues to have serious concerns about the adequacy of NRC efforts to reduce the vulnerability of nuclear power plants to radiological sabotage attacks. If a team of well-trained terrorists were to succeed in gaining forced entry to a nuclear power plant, within a matter of minutes it could do enough damage to cause a meltdown of the core and a failure of the containment structure. Such an attack would have a devastating and long-lasting impact on public health, the environment, and the economy. A groundswell of public opposition to nuclear power would likely result, making it difficult for utilities to continue to operate existing nuclear plants, much less to construct new ones.

The public has a right to know about the dangers that they may face from plants in their vicinity, and the NRC has a responsibility to ensure that emergency planning is based on the most accurate information and is conservative enough to provide ample protection. But the NRC is doing a disservice to the public by making misleading and confusing statements about the potential consequences of terrorist attacks or severe accidents at nuclear plants. It has backed away from its own publicly available pre-9/11 radiological assessments, and claims that more recent anal-

yses show that there is much less cause for concern. But the public must take these claims on faith, because the new assessments are all classified.

After the 9/11 attacks, the NRC repeatedly asserted that the public had little to fear from a jumbo jet attack on a nuclear plant, because of the plants' redundant safety systems, highly trained operators, robust structures, and emergency procedures. But the NRC admitted that it had never analyzed such attacks, so it commissioned classified vulnerability assessments from the national laboratories to determine what could actually happen.

After these studies were completed, the NRC then conceded that there was a small chance that such an attack could cause a radiological release, but maintained that the NRC's "emergency planning basis" would remain valid.[1] However, the NBC's emergency planning basis already includes, in principle, consideration of severe, Chernobyl-type accidents involving core melt and containment failure. So all the NRC's statement actually says is that a 9/11-style attack on a nuclear plant wouldn't cause an event worse than Chernobyl, which is not very reassuring. And, as I discuss below, in the event that such a calamity occurs, NRC's emergency planning procedures may help to limit the near-term deaths from acute exposure to radiation, but would have little impact on the large numbers of cancer fatalities that could result from lower but still significant exposures to the radioactive plume.

The effects of such attacks would be particularly severe for nuclear plants situated in densely populated metropolitan areas and near nerve centers of our economy, such as Indian Point, only 25 miles north of New York City. A study that I prepared last year for the environmental group Riverkeeper found that the consequences of a terrorist attack at one of the reactors at Indian Point could be catastrophic, with up to 44,000 deaths in the near-term from acute radiation poisoning, 500,000 deaths in the long-term from cancer, and economic damages that could exceed $2 trillion.[2] It is hard to conceive of a "dirty bomb" that could do as much damage. This study was performed using the same computer codes and radiological releases ("source terms") that NRC itself uses for conducting radiological assessments.

Another notable finding of the Indian Point study is the widespread extent of the contamination that can result from a nuclear plant attack. The calculations clearly showed that severe health consequences can occur at locations far downwind of the affected plant, with near-term fatalities occurring up to 60 miles away. An attack on Indian Point could be catastrophic not only for New York City but also for densely populated parts of New Jersey and Connecticut.

Perhaps the most troubling result of the study involved the doses to children from radioactive iodine exposure. Radioactive iodine can concentrate in the thyroid, delivering very high radiation doses to thyroid tissue and posing an elevated risk of thyroid cancer, particularly in children. One of the terrible legacies of the 1986 Chernobyl accident is the epidemic of thyroid cancer among children exposed to radioactive iodine, a causal relationship that has now been conclusively established.[3]

Potassium iodide (KI), if administered within a few hours of exposure to radioactive iodine, can be very effective in reducing the radiological impact. NRC's policy is to provide funds for purchase of KI, in states that request it, for individuals within the roughly circular, 10-mile-radius "plume exposure" emergency planning zone (EPZ). However, the results of the Indian Point study indicate that children hundreds of miles away from a nuclear power plant attack could receive exposures to the thyroid in excess of 5 rem, the dose that would trigger administration of KI under FDA guidelines. The current NRC policy appears to leave many children at serious risk in the event of a severe accident or terrorist attack at a nuclear plant.

The NRC's position is that there is no need for KI distribution more than ten miles away from any nuclear plant. But although the NRC doesn't like to point this out, this assessment is appropriate only for accidents in which the containment building remains intact and significantly reduces radiological releases to the environment. In the post-9/11 era, such an assumption should no longer form the basis for emergency planning decisions, given that terrorists capable of attacking a plant and causing a meltdown would also likely be able to breach the containment as well. A more prudent KI policy should be based on a more realistic radiological assessment that considers containment breach events and uses plume mapping, based on-

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[1] Statement submitted by Luis Reyes, U.S. Nuclear Regulatory Commission, to the Subcommittee on National Security, Emerging Threats and International Relations, Committee on Government Reform, U.S. House of Representatives, September 14, 2004, p. 8.

[2] Edwin S. Lyman, "Chernobyl-on-the-Hudson? The Health and Economic Impacts of a Terrorist Attack at the Indian Point Nuclear Plant," commissioned by Riverkeeper, Inc., September 2004.

[3] E. Cardis et al., "Risk of Thyroid Cancer After Exposure to 131I in Childhood," Journal of the National Cancer Institute 97 (2005) 724–32.

site-specific meteorological conditions, to determine the regions where KI is likely to be needed.

These dangers are not exclusive to plants in urban areas like Indian Point. Over the last fifteen years, suburban sprawl has led to substantial population growth in rural areas, some of them near formerly remote nuclear power plants. Preliminary UCS data based on U.S. Census figures indicate that between 1990 and 2000, the number of people living within the 10–mile emergency planning zones of many nuclear plants, including Calvert Cliffs in Maryland, Catawba in South Carolina, North Anna in Virginia, Shearon Harris in North Carolina and Comanche Peak in Texas, increased by 35 percent or more from 1990–2000—nearly three times the average population growth of the Nation during that period.

Moreover, the attack scenario evaluated in the Indian Point report was far from the worst case. For instance, the study assumed that the attack only caused damage to the reactor itself and not to the spent fuel pools, which remained fully functional after the attack. However, the spent fuel pools themselves contain enormous quantities of long-lived radionuclides, are not protected by containment buildings like the reactors themselves, and are vulnerable to zirconium cladding fires and fuel melting in the event of an extended interruption to their active cooling systems. As the recent National Academy of Sciences study on spent fuel pool risks has made clear, a terrorist attack on a spent fuel pool could, under some conditions, lead to the release of large quantities of radioactive materials to the environment.[4] Calculations that I performed for an article published last year in the Princeton-based journal *Science and Global Security* showed that a terrorist attack on a spent fuel pool alone could result in thousands of cancer deaths and economic damages in the range of hundreds of billions of dollars.[5]

PREVENTING TERRORIST SABOTAGE ATTACKS AND THEFTS OF NUCLEAR MATERIALS

There are several ways in which the NRC can strengthen its regulations for protecting the public from the threats of sabotage attacks on nuclear power plants and thefts of nuclear weapon-usable materials from Category I nuclear facilities. These include: (1) insuring that the "design basis threats" that facilities are required to protect against adequately represent the terrorist threats that those facilities actually face; (2) ensuring that force-on-force tests used to assess the adequacy of security measures at nuclear facilities are realistic and credible; (3) addressing the continuing problem of guard fatigue at nuclear plants; (4) reforming the implementation of "risk-informed regulation" to allow an increase in regulatory burdens when warranted; and (5) imposing the same standards for safety culture at the NRC as the NRC does for nuclear plants. I discuss each of these in turn below.

Design Basis Threat (DBT)

The DBT is a description of the size and other characteristics of the adversary group that certain nuclear facility licensees are required to design their security systems to protect against. There are different DBTs for the threat of radiological sabotage and for the threat of theft of "Category I" quantities of weapon-usable materials (2 kilograms or more of plutonium, 5 kilograms or more of highly enriched uranium). In April 2003, after a long deliberative process, the NRC issued revised DBTs to take into account the increased threat environment after the 9/11 attacks.

Nuclear power plant licensees and Nuclear Energy Institute officials were allowed to review and comment on the proposed radiological sabotage DBT, but members of the public were not. The NRC argues that the interests of the public were represented because it sought comment on the DBT from other agencies. In fact, most other agencies apparently were not very happy with the proposal. As Commissioner Edward McGaffigan wrote in 2003:

> ". . . every other Federal agency that reviewed the staff's proposed DBT, other than the FBI, felt there could be additional attributes in the DBT, but all of them declined to help us on where the line should be drawn between the primary responsibility of a regulated private sector guard force and the primary responsibility of government . . . the agencies instead answered what the overall threat might be, and in my personal view covered their bets so that they could never be accused of underestimating terrorists . . ." [6]

[4] Board on Radioactive Waste Management, National Research Council, "Safety and Security of Commercial Nuclear Fuel Storage," Public Report, National Academies Press, Washington, D.C., 2005, Executive Summary, p. 6.

[5] J. Beyea, E. Lyman, F. von Hippel, "Damages from a Major Release of 137Cs into the Atmosphere of the United States," Science and Global Security 12 (2004) 125–136.

[6] NRC Commissioner Edward McGaffigan, personal communication, May 16, 2003.

Ultimately, the NRC did not base the post-9/11 DBT on the maximum credible threat against U.S. critical infrastructure, as this comment suggests was the recommendation of most other agencies, but instead defined it as "the largest reasonable threat against which a regulated private guard force should be expected to defend under existing law."[7] Although the DBT is "safeguards information" and is not publicly available, one can infer from public statements by NRC officials that it is not commensurate with the 9/11 attack threat—that is, a large group of attackers, capable of acting in four coordinated teams, that is assisted by several insiders and may have multiple large aircraft at its disposal.

This means that even today, more than 3 years after 9/11, private nuclear plant security forces would not be able to repel an attack on the magnitude of 9/11 on their own, but would require the assistance of additional forces (e.g. local law enforcement, National Guard) at public expense. Yet there is still no systematic mechanism in place to evaluate these vulnerabilities and quickly ensure that sufficient resources are provided to remedy them. Attempts to address these security gaps, like the Department of Homeland Security's National Infrastructure Protection Plan, which was issued in interim form in February of this year, are a long way from being implemented.

While it is reasonable not to include members of the public in deliberations regarding sensitive details of the DBT, public confidence is hard to sustain when the public knows that industry representatives are full partners at the table, and the table is behind closed doors. There should be some way to give taxpayers a say in deciding where to draw the line between private and public obligations, since they will be responsible for paying for the public resources needed to supplement the security of private nuclear facilities. Moreover, this taxpayer subsidy will only continue to increase if, as some industry representatives want, the DBT will remain frozen from now on, with the government paying to provide the additional security needed if the threat level increases in the future.[8]

The NRC's current plan to revise its physical protection regulations through a rulemaking presents an opportunity to increase the transparency of its security decisionmaking, but only if the NRC makes every effort to maximize opportunities for public involvement and to minimize the amount of relevant information that is withheld from the public.

Congress should mandate an independent review of the methodology used by the NRC to develop the DBT and the adequacy of the DBT itself, in light of intelligence on known and emerging threats. The views of all other agencies should be seriously considered. An approach similar to that proposed in the House and Senate energy bills, which would require an interagency review of threats and assignments of responsibility for addressing them, would be a good start.

Force-on-Force Tests

A key aspect of a robust security program is force-on-force (FOF) testing. Security plans that look great on paper can have weaknesses that only become apparent during testing. UCS commends the NRC for instituting a mandatory FOF testing program, through its post-9/11 security orders, that will test the security of each plant site every 3 years. The credibility of this testing program is essential for public confidence. While the NRC has taken steps to make these tests more realistic, there are other issues that it must address to ensure the credibility of this program. Congress should consider legislation that would impose strict guidelines on the FOF testing program to ensure that these concerns and others are resolved.

The public must be able to trust the FOF tests. The public cannot have confidence in the outcomes of these tests unless their integrity is beyond reproach. NRC's award of the contract for the mock adversary team to be used in all FOF tests to Wackenhut, the same contractor that supplies the security officers for nearly half of US nuclear power plants, obviously presents the potential for conflicts of interest. While NRC asserts that it is rigorously guarding against the possibility that the tests could be compromised, the public has no choice but to take NRC at its word. In this regard, appearance is everything.

The FOF tests must be challenging. The NRC must ensure that the attack scenarios chosen for the FOF tests are sufficiently challenging to provide high assurance that the licensees' security programs are robust. In particular, they should

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[7] NRC Approves Changes to the Design Basis Threat and Issues Orders for Nuclear Power Plants to Further Enhance Security," press release, April 29, 2003.

[8] Michael Wallace, President, Constellation Group, Chairman of NEI Security Working Group and Chairman of the Nuclear Sector Coordinating Council, "Achieving Stability in a Post-9/11 Environment," NRC Regulatory Information Conference, Rockville, MD, March 8, 2005.

probe vulnerabilities in a licensee's protective strategy that are likely to be known by an insider in a top security position and could be exploited by real adversaries.

Also, FOF tests should not only test the ability of security forces to protect against the DBT, but should also evaluate the margin to failure of the security strategy with respect to increases in the threat beyond the DBT. Safety systems are typically designed with a margin to failure, so that they can continue to provide some protection even if design-basis accident conditions are exceeded. However, it is unclear if there is a comparable margin to failure with respect to security systems. The only way to determine this is to actually test the system with mock adversaries whose characteristics exceed the DBT in some respects.

Finally, the amount of time that licensees are given to prepare for FOF tests remains an issue. In a real attack, the element of surprise is one of the greatest advantages of the attacking force, but for practical reasons the NRC must give some advance warning of an impending test. This diminishes the usefulness of the test as an accurate measure of the state of security during day-to-day operations. Prior to 9/11, the NRC would inform licensees 6 to 10 months in advance. Recently, the Commission was informed in a public meeting that the NRC staff has reduced the period of advance warning to 2 months. However, this still allows far too much time for licensees to prepare for and rehearse for the test.

The FOF tests must not unreasonably restrict the capabilities of insiders. The regulatory DBT specifies that the external adversary force is assisted by an insider that can participate in an active role, a passive role, or both. However, in the FOF tests conducted before 9/11, the role of the insider was limited to passive activities such as providing plant information to the external adversary team. But an active insider, who might be anyone from a control room operator to an armed responder, could give an enormous advantage to an adversary, and the serious threat such an insider could pose should not be ignored. Protective strategies should be developed with due consideration to the damage that could be caused by an active insider in any capacity, and those strategies should be fully tested in the FOF program.

The grading process for the FOF tests must be clear, understandable, and sensible. When NRC does a safety inspection and finds a problem, it uses a "significance determination process" (SDP) to evaluate the severity of the finding. For the most serious problems, such as those, that have a high probability of leading to a core meltdown if left uncorrected, the process would generate a "RED" finding, which triggers a predetermined set of enforcement actions. For instance, for allowing the hole in the reactor vessel head to develop at Davis-Besse, First Energy clearly deserved, and got, a RED finding.

However, when the NRC tried to apply the same logic to evaluating the findings of FOF tests back in 2000, it ran into problems. For example, since the adversaries were considered to have achieved their goal in a FOF if they could have done enough damage to safety systems to cause a meltdown, the licensee would get a RED finding any time the adversaries "won" a FOF. Since the licensees were losing FOF drills about 50 percent of the time, they were not happy about this result. Consequently, the NRC suspended application of the process to FOF tests and went back to the drawing board.

Shortly before the 9/11 attacks, when this issue was still being discussed in public, the Nuclear Energy Institute made a proposal for an SDP process in which a FOF test could never result in a RED finding, no matter how badly a licensee's security force performed. The public never found out if the NRC adopted this proposal, since the 9/11 attacks intervened and the security SDP methodology was designated as "safeguards information." However, there was a public discussion of the SDP issue during a Commission briefing in March, and it appeared that the NRC is still experiencing problems with implementation of the security SDP, including disagreements with licensees over the results.

The public cannot have confidence in the FOF program if it does not have assurance that NRC is administering the most serious penalties when the most serious security violations occur.

GUARD FATIGUE

Another critical issue is guard fatigue. The job of security personnel at nuclear plants is a demanding and stressful one. They must be poised to respond to an attack with little or no warning during their entire shift. And if an attack comes, they must respond consistently at the highest level of performance. Strong safeguards must be in place to ensure that security officers get enough rest to do their job effectively. In 2003, after numerous reports that security officers around the country were being compelled by management to work unreasonably long hours, such as six consecutive twelve-hour shifts per week, the NRC imposed an order putting modest

restrictions on their work hours. But UCS and other watchdog groups continue to hear complaints that licensees are not fully complying with the order or are exploiting loopholes in it, and that the NRC is not aggressively enforcing the order. If these complaints have merit, this state of affairs needs to be immediately addressed.

RISK-INFORMED REGULATION: STILL A SINGLE-EDGED SWORD

One of the most glaring examples of the NRC's slant toward the interests of licensees can be found in its selective implementation of "risk-informed regulation." This is a process in which safety regulations are reviewed, using probabilistic risk assessment techniques, to evaluate their impact on radiological risk to the public. Those regulations that are determined not to have a significant impact on reducing risk can then be scrapped.

The NRC has said that risk-informed regulation should be a "double-edged sword"—that is, the process should be used not only to eliminate regulations and reduce regulatory burden, but also to strengthen regulations when gaps in protection are found that have high risk significance. But, as UCS Reactor Safety Engineer David Lochbaum has said, the NRC's "two-edged risk-informed sword" is "razor-sharp on one side, NERF-like on the other."[9] In other words, it is much more effective in reducing regulatory burdens than in imposing new requirements.

When confronted with this criticism, the NRC has offered a counterexample: its revision of regulation 10 C.F.R. 50.44, which concerns the control of combustible gases (such as hydrogen) during accidents to prevent an explosion that could breach containment. However, a look at the specifics of this case demonstrates otherwise.

The NRC's analysis found that most of the requirements for controlling hydrogen generation have little impact on the risk of containment failure. But it also found that there was one case in which the regulations did not adequately limit the risk of containment failure for certain types of plants during station blackouts, in which both offsite and onsite power is lost. Of the plants in this category, nine are pressurized-water reactors with ice-condenser containments, such as Catawba I and II in South Carolina, and four are boiling-water reactors with Mark III containments, such as Perry in Ohio. These plants have significantly smaller and weaker containments than other U.S. plants, and in the event of a hydrogen explosion, studies show that there would be a near certainty of containment failure,[10] resulting in a catastrophic radiological release. For this reason, NRC requires that these plants be provided with hydrogen igniters to burn off hydrogen generated during an accident before it can reach an explosive concentration. However, these igniters require AC power to operate, so in the event of a station blackout, they would not be available, and operators would be helpless to prevent a containment failure.

The NRC revised 10 CFR 50.44 by throwing out all the provisions that it determined were unnecessary. However, it also decided to evaluate whether it would be cost-effective to require that ice-condenser and Mark III plants be equipped with additional backup power supplies to ensure that the igniters would be available during a blackout. After several years of detailed analyses, the NRC decided that this problem could be fixed inexpensively and that the reduction in risk was well worth the cost. This seemed to be a win-win-win situation: the public would win because a serious risk would be mitigated; licensees would win because the fix was quick and not prohibitively expensive, and the NRC would win by being able to show naysayers that it wasn't afraid to impose additional requirements when necessary.

However, 4 years later, virtually nothing has happened. Boiling-water reactor operators insisted on imposing strict design criteria on replacement power systems that drove up their projected cost until they no longer looked justifiable. And not only has the NRC abandoned plans to fix the problem through a rulemaking, it has even declined to issue a generic letter requiring licensees to make the necessary changes. It is now relying on voluntary commitments, but some licensees may not even follow through with those, claiming that they are too expensive. Meanwhile, people living near those plants remain at an unnecessarily high risk of being victims of a Chernobyl-type accident. If uncorrected, this problem will pose an even greater risk if the Catawba and McGuire ice-condenser plants begin to utilize large quantities of plutonium-bearing MOX fuel, which can increase both the probability and consequences of a severe accident or a successful radiological sabotage attack. The second edge of NRC's risk-informed sword has yet again proved to be a dull blade.

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[9] Presentation by David Lochbaum at the NRC Nuclear Safety Research Conference, October 30, 2002.

[10] U.S. NRC, "Director's Status Report on Generic Activities," April 2005, p. 90.

SAFETY CULTURE AT THE NRC

My colleague at UCS, David Lochbaum, who is an expert in safety issues, was not able to be here today. Here I would like to outline his views on the need for an improved safety culture at the NRC.

According to the NRC, a safety culture "*can be characterized by a willingness on the part of licensee staff to raise and document safety issues to resolve risk-significant equipment and process deficiencies promptly, adhere to written procedures, conduct effective training, make conservative decisions, and conduct probing self-assessments.*"

In recent years, the NRC did not allow the Millstone and Davis-Besse reactors to restart until their safety cultures had been restored to acceptable levels. However, independent assessments performed by the General Accounting Office and the NRC Inspector General of the safety culture within NRC conclude it is as bad as, if not worse, than that at Millstone or Davis-Besse.[11] For example, nearly 50 percent of NRC staffers in a recent survey reported feeling unable to raise safety concerns without fear of retaliation and nearly one-third of NRC staffers who had raised safety concerns felt they had suffered harassment and/or intimidation as a result.

These assessments of the NRC safety culture are consistent with reports UCS has received from NRC staffers who have called with accounts of NRC inspectors being instructed by their managers not to find any violations, of NRC managers telling inspectors not to write up safety problems they found at nuclear plants, and of NRC managers ignoring the written objections of the agency's subject matter experts when making decisions about safety. Such behavior is unacceptable and must be corrected.[12]

Thus far, the NRC has failed to do anything to remedy its own safety culture problems. The NRC will not allow a nuclear reactor to operate if it feels the work force labors under a poor safety culture. By the same token, the NRC's own staff must function in a good safety culture if we are to have confidence in its oversight of the entire reactor fleet. The safety culture within the NRC must be monitored and restored to at least the level that the NRC deems minimally acceptable for operating nuclear plants.

SUMMARY

The NRC has repeatedly testified since 9/11 that it opposes many of the legislative initiatives proposed in both houses of Congress to strengthen nuclear plant security on the grounds that they are unnecessary. UCS believes that legislative reform is necessary and appropriate to ensure that design basis threats are realistic and conservative; that required resources are made available for protection against beyond-design-basis threats; that security testing is effective and credible; that emergency planning procedures are designed to protect all individuals at risk from a nuclear plant sabotage attack; and that protections against theft of nuclear weapon-usable materials are strengthened, not weakened. We look forward to working with you to ensure that operating nuclear power plants remain as safe and secure as possible.

RESPONSE BY DR. EDWIN LYMAN TO ADDITIONAL QUESTION FROM SENATOR JEFFORDS

Question. Since our last oversight hearing, a number of concerns have been raised about the content, scope and frequency of force on force testing. These commando style drills are an important part of the training for our security forces at nuclear plants.

Your testimony alluded to this, but would you describe in greater detail how you think the requirements for the performance of these tests should be modified to en-

[11] GAO on NRC: United States General Accounting Office, "Nuclear Regulation: NRC Staff Have Not Fully Accepted Planned Changes," GAO/RCED–00–29, January 2000.

IG on NRC: United States Nuclear Regulatory Commission Inspector General, "Special Evaluation: OIG 2002 Survey of NRC's Safety Culture and Climate,' OIG–03–A–03, December 11, 2002.

Millstone: Presentation by Little Harbor Consultants to Nuclear Regulatory Commission, "Update on LHC Oversight Activities at Millstone," July 22, 1997.

Davis-Besse: Letter from FirstEnergy Nuclear Operating Company to Nuclear Regulatory Commission, "Submittal of the Report Titled 'Safety Culture Evaluation of the Davis-Besse Nuclear Power Station,' dated April 14, 2003," April 23, 2003.

[12] Letter from David Lochbaum, to NRC Chairman Nils Diaz, "Kudos and Mea Culpa on Safety Conscious Work Environment," February 2, 2004.

sure that guards are not "tipped off" about the content of these drills and that they are true attack simulations? What do you think NRC's role should be in ensuring that nuclear plants aren't conducting a self assessment?

Response. Without rigorous regulatory supervision and a strict "firewall" between mock adversaries and site defense forces, performance tests can be easily manipulated. The Department of Energy Inspector General's report of January 2004, "Protective Force Performance Test Improprieties," documents the many ways in which Wackenhut, which has been the security contractor at the Oak Ridge National Laboratory (ORNL) since January 2000, as well its predecessors, engaged in practices at ORNL during security performance tests to give unfair advantages to the defending force, thereby compromising the tests and rendering their results "tainted and unreliable."

While it will never be possible to completely eliminate the possibility of collusion of mock adversaries with site security officers, the NRC could do a number of things to reduce it. First, the NRC should reverse its decision to accept the Nuclear Energy Institute's award to Wackenhut for the contract for establishing the Composite Adversary Force (CAF) and should instead oversee the formation, management and training of a mock adversary force that is completely independent of site security forces. The NRC continues to retain independent "subject matter expert" contractors with considerable experience in paramilitary operations who advise the mock adversary forces and choose the exercise scenarios. The adversary force itself could be drawn from the same community that provides the subject matter experts or from the pool of former military and Special Forces personnel who now work for private security firms such as Blackwater USA. The NRC also must provide more stringent oversight over the "controllers" who act as referees during the tests, to ensure that they are making fair calls.

Second, NRC regulations should be revised to make clear that the force-on-force tests are enforceable inspections and that any attempt to compromise them would be regarded as a serious violation that could result in both civil and criminal penalties. The Department of Energy requires personnel who have access to test scenario information before a test to execute "trusted agent" agreements that place restrictions on their ability to communicate that information. We do not know whether the NRC now requires similar agreements.

In addition, the NRC must remain vigilant to ensure that force-on-force exercises do not become stage plays put on for the NRC's benefit. The test scenarios should not be rote repetitions of often-rehearsed drills. To this end, it is essential that the scenarios chosen for the force-on-force tests by the NRC subject matter expert contractors be challenging and probe vulnerabilities in the protective strategy. The contractors' ability to choose challenging scenarios depends on the amount of information about licensees' protective strategies that is provided to them prior to the force-on-force tests.

The NRC design basis threat regulations specify that the external attacking force must be assisted by an insider who is a "knowledgeable individual." The regulations place no restrictions on what position this insider may occupy. In particular, the insider could be someone with a high position in the security organization, such as the armed response force commander. This individual would know sensitive details of the armed response procedures, such as how responders might be redeployed from their normal positions during an attack.

In accordance with this regulation, the NRC's subject matter expert contractors should be aware of the licensee's protective strategy when choosing the scenarios for the force-on-force tests. In the Operational Safeguards Response Evaluation (OSRE) program that ended in 2001, it is my understanding that this knowledge was obtained by allowing the NRC contractors to participate in tabletop exercises conducted prior to the full-scale exercises. This approach enabled the contractors to search for weaknesses in the protective strategy that would be known to well-placed insiders.

However, industry representatives complained at the time that this approach gave an unfair advantage to the mock adversaries by giving them access to more detailed information than real terrorists would be likely to have. The Nuclear Energy Institute's 2000 guidelines for a proposed security "self-assessment" program placed strict limitations on the information that would be provided to the NRC contractors prior to force-on-force tests. For instance, the contractors would be allowed to observe the fixed positions of the armed responders but would not be given information about how the armed responders would be redeployed during an attack. Such artificial limitations would impair the ability of the contractors to detect weaknesses in the protective strategy, and they should not have a part in a realistic force-on-force test program.

One issue raised in the DOE Inspector General's report on the ORNL test improprieties was the practice of having "stand-by" protective force personnel available during performance tests who would not normally have been available for armed response during a shift. The participation of such auxiliary personnel can cause confusion about the outcome of a force-on-force test. While the NRC no longer allows licensees to augment their security forces above security plan commitments solely in preparation for a test, the NRC must also ensure that only personnel that are wholly committed to armed response be allowed to participate in exercises that test protection against the design basis threat.

At ORNL, the security contractor would also assign the most capable personnel to the shifts when performance tests would be conducted. To prevent this from occurring, the NRC should reduce the time of advance warning of performance tests to the extent that attempts by licensees to rearrange work schedules prior to the test would be easily detectable.

RESPONSE BY DR. EDWIN LYMAN TO ADDITIONAL QUESTION FROM SENATOR LAUTENBERG

Question. The Oyster Creek nuclear facility in my state will turn 40 years old in 2009, and as you're aware the re-licensing decision is a very controversial issue in my state. The operators claim they have already replaced most of the plant's parts so that it is not actually 40 years old. Would you give me your view on the future of Oyster Creek?

Response. The following response was submitted by Dave Lochbaum, UCS Nuclear Safety Engineer.

While the owner of the Oyster Creek nuclear plant has replaced some of the plant's equipment (such as valve gaskets, electrical fuses, etc.), most of the structures and components within the scope of the Nuclear Regulatory Commission's license renewal regulation date back to original construction (e.g., reactor pressure vessel, reactor containment building, etc.).

There is nothing magical about the 40-year operating license initially granted for Oyster Creek. It does not guarantee that the facility is safe up to age 40 and unsafe afterwards. But countless engineering, maintenance, and regulatory decisions were made in the past under the assumption that Oyster Creek would only operate for 40 years.

The NRC's license renewal rule attempts to verify past assumptions regarding equipment condition. This rule requires Oyster Creek's owner to have aging management programs for important systems, structures, and components. The aging management programs are supposed to monitor equipment conditions so as to allow replacements and/or repairs prior to safety margins being compromised.

Unfortunately, many events at U.S. nuclear plants, including Oyster Creek, demonstrate that these aging management programs are inadequate. In some cases, such as the February 2000 steam generator tube rupture at Indian Point and the October 2000 coolant leak at Summer, the events are caused by aging management programs that look for potential damage using the wrong detection methods. Damage that is present and detectable has been overlooked. In other cases, such as the jet pump failure at Quad Cities and the March 2001 coolant leak at Oconee, the events are caused by aging management programs that look for potential damage in the wrong locations. By looking in the right places with the wrong detectors and looking in the wrong places with the right detectors, the aging management programs are not preventing safety margins from being compromised. To remedy this shortfall, the NRC must require inspections to be performed using diverse monitoring techniques to increase their reliability and must require the scope of the inspections to be broadened to reduce the frequency of "misses."

The NRC's license renewal rule utterly fails to verify past regulatory assumptions. Oyster Creek does not comply with today's nuclear safety standards. Instead, it is supposed to comply with an array of standards spanning four decades. Oyster Creek was initially licensed in the 1960s by NRC's predecessor, the Atomic Energy Commission (AEC). As the AEC and then the NRC subsequently adopted new regulations, Oyster Creek was sometimes grandfathered from them, sometimes exempted from them, and sometimes required to meet them. Each of these regulatory decisions was made in isolation and based on the assumption Oyster Creek would only operate for 40 years. The NRC's license renewal rule must formally compare Oyster Creek's applicable regulatory requirements to today's safety standards to either verify equivalent protection of public health or identify shortfalls that must be remedied before the facility operates for two more decades.

Collectively, these two measures would provide reasonable assurance that Oyster Creek was sufficiently safe today and would not decline from this safety level during the license renewal period. Absent these measures, there is little confidence that Oyster Creek is safe enough today or will remain safe enough during the next 20 years.

CHERNOBYL ON THE HUDSON?

THE HEALTH AND ECONOMIC IMPACTS OF A TERRORIST ATTACK AT THE INDIAN POINT NUCLEAR PLANT

Edwin S. Lyman, PhD
Union of Concerned Scientists
September 2004

Commissioned by Riverkeeper, Inc.

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EXECUTIVE SUMMARY

Since 9/11, the specter of a terrorist attack at the Indian Point nuclear power plant, thirty-five miles upwind from midtown Manhattan, has caused great concern for residents of the New York metropolitan area. Although the Nuclear Regulatory Commission (NRC) ordered modest security upgrades at Indian Point and other nuclear power plants in response to the 9/11 attacks, the plants remain vulnerable, both to air attacks and to ground assaults by large terrorist teams with paramilitary training and advanced weaponry. Many question whether the NRC's security and emergency planning requirements at Indian Point are adequate, given its attractiveness as a terrorist target and the grave consequences for the region of a successful attack.

This report presents the results of an independent analysis of the health and economic impacts of a terrorist attack at Indian Point that results in a core meltdown and a large radiological release to the environment. We find that, depending on the weather conditions, an attack could result in as many as 44,000 near-term deaths from acute radiation syndrome or as many as 518,000 long-term deaths from cancer among individuals within fifty miles of the plant. These findings confirm that Indian Point poses a severe threat to the entire New York metropolitan area. The scope of emergency planning measures should be promptly expanded to provide some protection from the fallout from an attack at Indian Point to those New York area residents who currently have none. Security at Indian Point should also be upgraded to a level commensurate with the threat it poses to the region.

A 1982 study by Sandia National Laboratories found that a core meltdown and radiological release at one of the two operating Indian Point reactors could cause 50,000 near-term deaths from acute radiation syndrome and 14,000 long-term deaths from cancer. When these results were originally disclosed to the press, an NRC official tried to reassure the public by saying that the kind of accident the study considered would be less likely than "a jumbo jet crashing into a football stadium during the Superbowl."

In the post-9/11 era, the possibility of a jumbo jet crashing into the Superbowl --- or even a nuclear power plant --- no longer seems as remote as it did in 1982. Nonetheless, NRC continues to argue that the 1982 Sandia report is unrealistic because it focused on "worst-case" accidents involving the simultaneous failure of multiple safety systems, which are highly unlikely to occur by chance. But when the potential for terrorist attacks is considered, this argument no longer applies. "Worst-case" scenarios are precisely the ones that terrorists have in mind when planning attacks.

Both NRC and Entergy, the owner of Indian Point, assert that even for the most severe terrorist attack, current emergency plans will be adequate to protect residents who live in the evacuation zone within 10 miles of the plant. They also say that there will be no significant radiological impact on New York City or any other location outside of the 10-mile zone. Accordingly, NRC has opposed proposals made after 9/11 to extend the emergency planning zone around Indian Point. However, NRC and Entergy have not

provided the public with any documentation of the assumptions and calculations underlying these claims.

In view of the lack of public information available on these controversial issues, we carried out an independent technical analysis to help inform the debate. Our calculations were performed with the same state-of-the-art computer code that NRC uses to assess accident consequences. We used the NRC's guidance on the radiological release from a core meltdown, current estimates of radiation risk, population data from the 2000 census, and the most recent evacuation time estimate for the 10-mile Indian Point emergency planning zone. Following the format of the 1982 Sandia report, we calculated the numbers of near-term deaths from acute radiation syndrome, the numbers of long-term deaths from cancer, and the maximum distance at which near-term deaths can occur. We evaluated the impact of both evacuation and sheltering on these outcomes. We also estimated the economic damages due to the long-term relocation of individuals from contaminated areas, and the cost of cleanup or condemnation of those areas.

The health and environmental impacts of a large radiological release at Indian Point depend strongly on the weather conditions. We have carried out calculations for over 140,000 combinations of weather conditions for the New York area and wind directions for the Indian Point site, based on a year's worth of weather data. For this data set, we have determined the average consequences, the peak consequences, and the consequences for "95th percentile" weather conditions (in other words, only 5% of the weather sequences analyzed resulted in greater consequences).

We believe that the 95th percentile results, rather than the average values, represent a reasonable assessment of the likely outcome of a successful terrorist attack, since such attacks would most likely not occur at random, but would be timed to coincide with weather conditions that favor greater casualties. Attacks capable of causing the peak consequences that we calculate would be difficult to achieve because of inaccuracies in weather forecasts, restricted windows of opportunity and other factors, but remain within the realm of possibility.

For a successful attack at one of the two operating Indian Point reactors, we find that

- The number of near-term deaths within 50 miles, due to lethal radiation exposures received within 7 days after the attack, is approximately 3,500 for 95th percentile weather conditions, and approximately 44,000 for the worst case evaluated. Although we assumed that the 10-mile emergency planning zone was entirely evacuated in these cases, this effort was inadequate because (according to Entergy's own estimate) it would take nearly 9.5 hours to fully evacuate the 10-mile zone, whereas in our model the first radiological release occurs about two hours after the attack.

- Near-term deaths can occur among individuals living as far as 18 miles from Indian Point for the 95th percentile case, and as far as 60 miles away in the worst case evaluated. Timely sheltering could be effective in reducing the number of

near-term deaths among people residing outside of the 10-mile emergency planning zone, but currently no formal emergency plan is required for these individuals.

- The number of long-term cancer deaths within 50 miles, due to non-acutely lethal radiation exposures within 7 days after the attack, is almost 100,000 for 95th percentile weather conditions and more than 500,000 for the worst weather case evaluated. The peak value corresponds to an attack timed to coincide with weather conditions that maximize radioactive fallout over New York City.

- Based on the 95th percentile case, Food and Drug Administration guidance would recommend that many New York City residents under 40, and children in particular, take potassium iodide (KI) to block absorption for radioactive iodine in the thyroid. However, there is no requirement that KI be stockpiled for use in New York City.

- The economic damages within 100 miles would exceed $1.1 trillion for the 95th percentile case, and could be as great as $2.1 trillion for the worst case evaluated, based on Environmental Protection Agency guidance for population relocation and cleanup. Millions of people would require permanent relocation.

We hope that this information will be useful to Federal, State and local homeland security officials as they continue to develop plans to protect all those at risk from terrorist attacks in the post-9/11 world.

INTRODUCTION

(a) The terrorist threat to nuclear power plants

Public concern about the vulnerability of nuclear power plants to catastrophic acts of sabotage soared in the aftermath of the September 11 terrorist attacks. There is ample justification for this concern.

Soon after the 9/11 attacks, the Nuclear Regulatory Commission conceded that U.S. nuclear power plants were not designed to withstand the high-speed impact of a fully fueled, modern passenger jet. The report of the 9/11 Commission has revealed that al Qaeda considered attacks on nuclear plants as part of their original plan, but declined to do so primarily because of their mistaken belief that the airspace around nuclear power plants in the U.S. was "restricted," and that planes that violated this airspace would likely be shot down before impact.[1]

But al Qaeda is surely now aware that no such restrictions were in place on 9/11. And it is clear from press reports that even today, no-fly zones around nuclear plants are imposed only at times of elevated threat level, and are limited in scope to minimize their economic impact on the aviation industry. This policy reflects a confidence in the ability of the intelligence community to provide timely advance warning of a surprise attack that --- given the 9/11 example --- is not entirely warranted. Moreover, even when no-fly zones are in place around nuclear plants, they are not likely to be effectively enforced. For instance, the U.S. government does not require that surface-to-air anti-aircraft protection be provided at nuclear plants, although such defenses have been routinely employed in Washington, D.C. since the 9/11 attacks.

In addition to the aircraft threat, many have begun to question the adequacy of physical security at nuclear plants to protect against ground-based, paramilitary assaults, in view of revelations that thousands of individuals received sophisticated training in military tactics at al Qaeda camps in Afghanistan. Press reports have documented many security failures at nuclear plants around the country, and have called attention to the troubling statistic that during a series of security performance tests in the 1990s, guard forces at nearly 50% of US plants failed to prevent mock terrorist teams from simulating damage that would have caused meltdowns had they been real attacks. This information, which was widely available but largely ignored before 9/11, suddenly became far more alarming in the new threat environment.

Today, the danger of a terrorist attack at a nuclear power plant in the United States --- either from the air or from the ground --- is apparently as great as ever. According to a January 14, 2004 speech by Robert L. Hutchings, Chairman of the National Intelligence Council (NIC),[2]

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[1] *The 9/11 Commission Report, Authorized Edition*, W.W. Norton, New York, 2004, p. 245.
[2] Robert L. Hutchings, "Terrorism and Economic Security," speech to the International Security Management Organization, Scottsdale, AZ, January 14, 2004.

> "targets such as nuclear power plants ... are high on al Qa'ida's targeting list as a way to sow panic and hurt our economy ... The group has continued to hone its use of transportation assets as weapons ... although we have disrupted several airline plots, we have not eliminated the threat to airplanes. There are still al Qa'ida operatives who we believe have been deployed to hijack planes and fly them into key targets ... Al Qa'ida's intent is clear. Its capabilities are circumscribed but still substantial. And our vulnerabilities are still great."

More recently, the 9/11 Commission concluded that "major vulnerabilities still exist in cargo and general aviation security. These, together with inadequate screening and access controls, continue to present aviation security challenges."[3]

(b) The Nuclear Regulatory Commission: an agency in denial

Since 9/11, members of the public, non-profit groups and lawmakers across the United States have been calling for major security upgrades at nuclear power plants, including consideration of measures such as military protection against ground assault and anti-aircraft defenses against jet attack. Yet the response of the Nuclear Regulatory Commission (NRC), the agency that regulates both the safety and security of US nuclear reactors, has not been commensurate with the magnitude of the threat.[4] And the Department of Homeland Security, the agency charged with coordinating the defense of the entire US critical infrastructure against terrorist attacks, appears to be merely following NRC's lead.[5]

Notwithstanding a steady stream of FBI warnings citing nuclear power plants as potential terrorist targets, NRC continues to maintain that there is no need to consider measures that could reduce the vulnerability of nuclear plants to air attack. NRC's position is that "the best approach to dealing with threats from aircraft is through strengthening airport and airline security measures."[6]

As it became clear that NRC was not going to require the nuclear industry to protect nuclear plants from attacks on the scale of September 11, some groups began calling for plants to be shut permanently. Because many of the most dangerous fission products in a nuclear reactor core decay rapidly after shutdown, the health consequences of a terrorist attack on a shutdown nuclear reactor would be significantly lower than those of an attack on an operating reactor.[7]

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[3] *9/11 Commission Report* (2004), op cit., p. 391.
[4] D. Hirsch, D. Lochbaum and E. Lyman, "NRC's Dirty Little Secret," *Bulletin of the Atomic Scientists*, May/June 2003.
[5] E. Lyman, "Nuclear Plant Protection and the Homeland Security Mandate," Proceedings of the 44th Annual Meeting of the Institute of Nuclear Materials Management, Phoenix, Arizona, July 2003.
[6] US Nuclear Regulatory Commission, "Frequently Asked Questions About NRC's Response to the 9/11/01 Events," revised March 15, 2004. On the NRC web site: http://www.nrc.gov/what-we-do/safeguards/911/faq.html#3.
[7] Calculations by the author, using the computer code MACCS2, indicate that for an attack occurring at twenty days after reactor shutdown and resulting in core melt and loss of containment, the number of early fatalities from acute radiation sickness would be reduced by 80% and the number of latent cancer fatalities

Public concern has been greatest for those plants seen as prime terrorist targets because of their symbolic importance or location near large population and commercial centers, such as the Indian Point nuclear power plant in Westchester County, New York, whose two operating reactors are situated only 24 miles from the New York City limits, 35 miles from midtown Manhattan and in close proximity to the reservoir system that supplies drinking water to nine million people. The post-9/11 movement to shut down Indian Point has attracted a level of support from the public and elected officials not seen since the early 1980s, including calls for shutdown by over 400 elected officials and over 50 municipalities.

In response to this challenge, NRC, Entergy (the owner of Indian Point), other nuclear utilities, and their trade group in Washington, the Nuclear Energy Institute (NEI), have undertaken a massive public relations campaign to assuage public fears about the risk of terrorism at Indian Point. First, they assert that a combination of robust nuclear plant design, physical security and redundant safety measures would be able to stop any terrorist attack from causing significant damage to the reactor core. Second, they argue that even if terrorists were to successfully attack Indian Point and cause a large radiological release, the public health consequences could be successfully mitigated by execution of the emergency plans already in place for residents within the 10-mile-radius "emergency planning zone" (EPZ). And third, they claim that outside of the 10-mile EPZ, exposures would be so low that no special precautions would be necessary to adequately protect the public from radiation, other than possible interdiction of contaminated produce and water.[8]

A typical example of the third argument can be found in a recent letter the NRC sent to Alex Matthiessen, Executive Director of Riverkeeper:[9]

> "Outside of 10 miles, direct exposure is expected to be sufficiently low that evacuation or sheltering would not be necessary. Exposure to a radioactive plume would not likely result in immediate or serious long-term health effects. Consideration of public sheltering and evacuation in emergency plans is very conservative and recommended at very low dose levels, well below the levels where health effects would be expected to occur."

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resulting from lower exposures would be reduced by 50%, compared to an attack when the reactor is operating at full power. This calculation does not consider an attack on the storage pools for the highly radioactive spent fuel, which could result in significant long-term radiological contamination over a wide area and enormous economic consequences. For an extensive discussion of this threat, as well as an analysis of approaches for mitigating it, see R. Alvarez et al., "Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States," *Science and Global Security* **11** (2003) 1-51.

[8] The NRC defines two "emergency planning zones," or EPZs. The 10-mile "plume exposure" EPZ is the region where evacuation or other actions could be ordered to protect the public from coming into contact with an atmospheric release of radioactivity. The 50-mile "ingestion" EPZ is the region where interdiction of agricultural products and water supplies could be ordered to prevent the consumption of contaminated produce. No evacuation planning is required for individuals residing within the ingestion EPZ but outside of the plume exposure EPZ.

[9] Letter from Cornelius F. Holden, Jr., Office of Nuclear Reactor Regulation, US NRC, to Alex Matthiessen, Riverkeeper, September 30, 2003.

The purpose of this report is to address these three claims, with an emphasis on the second and third, by conducting a quantitative assessment of the potential consequences of a terrorist-induced radiological release at Indian Point for individuals both within and without the 10-mile EPZ, including residents of New York City.

There is a considerable need today for an independent study of these questions. At a time when the importance of rigorous emergency planning for catastrophic terrorist attacks is obvious, it is essential that responsible officials be fully apprised of the facts, especially if they contradict long-held assumptions and biases. The lives of many people could be put at jeopardy if emergency plans are not designed with the most accurate information at hand.

This means, in particular, that the emergency planning process should be designed to account for the full spectrum of potential consequences, including so-called "fast-breaking" release scenarios in which radioactive releases to the environment would begin within about thirty minutes after an attack. This was one of the major conclusions of the report carried out for the government of New York State by James Lee Witt Associates.[10] Certain terrorist attack scenarios could be capable of causing such rapid releases.

But NRC and the Federal Emergency Management Agency (FEMA) continue to be reluctant to require testing of fast-breaking radiological releases in emergency planning exercises, asserting that such events are highly unlikely to occur.[11] However, this argument is no longer relevant in an age when terrorists have acquired unprecedented levels of technical expertise, and are actively targeting critical infrastructure facilities with the intent to maximize casualties and economic damages. If current emergency plans cannot successfully cope with all credible terrorist-induced events, they should be upgraded. If upgrading to a sufficiently protective level is so cumbersome as to be practically impossible, then other options, including plant shutdown, should not be ruled out.

Members of the public deserve to be fully informed of the potential consequences for their health and property of a successful terrorist attack at Indian Point, so that they can prepare for an attack in accordance with their own judgment and willingness to accept risk. This principle is consistent with the guidance of the Department of Homeland Security, whose Web site www.ready.gov advises that "all Americans should begin a process of learning about potential threats so we are better prepared to react during an attack." Sources of technical information other than NRC and the nuclear industry are

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[10] James Lee Witt Associates, *Review of Emergency Preparedness of Areas Adjacent to Indian Point and Millstone*, March 2003, Executive Summary, pg. x.

[11] Although it was anticipated that the widely publicized June 8, 2004 emergency planning exercise at Indian Point would involve a "fast-breaking" release, NRC in fact chose a scenario in which no release at all occurred. It was assumed that terrorists attacked the plant with a jet aircraft but missed the reactor and only managed to crash into the switchyard, causing a loss of off-site power but not enough damage to result in a radiological release. Thus the exercise provided no information as to the effectiveness of the Indian Point emergency plan in protecting residents of the EPZ from injury had the plane actually hit its target and initiated the damage scenario that is assessed in this report.

also essential to facilitate a factually accurate and honest discussion of the risks and benefits of continued operation of Indian Point in the post-9/11 era.

Some observers may criticize the public release of this report as irresponsible because they believe it (1) could assist terrorists in planning attacks, or (2) could interfere with the successful execution of emergency plans by unnecessarily frightening members of the public who the authorities claim are not at risk.

We are acutely aware of such concerns and, after careful consideration, have concluded that they do not have merit. We have reviewed this report carefully and omitted any information specific enough to be useful to terrorists seeking to attack Indian Point. Unfortunately, far more detailed information about nuclear plant design, operation and vulnerabilities than this report contains has already been --- and continues to be --- widely disseminated. For example, a paper written by staff of the Oak Ridge National Laboratory (ORNL) and the Defense Threat Reduction Agency (DTRA), published in 2004 in a technical journal and available on the Internet, contains a diagram of a generic nuclear power plant indicating where truck bombs of various sizes could be detonated in order to stage an attack with a 100% probability of core damage.

There can be little doubt that al Qaeda and other terrorist organizations are already well aware of the severity of the consequences that could result from an attack at Indian Point. It is NRC and FEMA that seem not to appreciate this risk, and it is to them above all that we direct this study. We also believe that there is a considerable cost, but no apparent benefit, to withholding information that could help people to protect themselves in the event of a terrorist attack at Indian Point. Better information will enable better coordination of all populations at risk and help to avoid situations where some individuals take inappropriate actions that endanger others.

This report would not have been necessary had we seen any indication that NRC and other government authorities fully appreciate the seriousness of the risk to the public from radiological sabotage, or if certain members of the Nuclear Regulatory Commission had not made statements regarding severe accident consequences and risks that contradicted the results of quantitative analyses developed and refined over several decades by NRC's own technical staff and contractors.

For instance, at a recent briefing on NRC's emergency preparedness program, NRC Commissioner Edward McGaffigan, comparing the radiological exposure from a reactor accident to air travel, radon and other sources of exposure to natural radioactivity, said that[12]

> "...the order of magnitude of the release is similar to all of these other things in people's lives and they should not panic over a few hundred millirem or even a couple of rem ... but it's this radiation phobia, absolutely inflamed by these anti-

[12] US NRC, *Briefing on Emergency Preparedness Program Status*, Public Meeting, September 24, 2003, transcript, p. 73.

> nuclear groups putting out their misinformation that actually hurts emergency planning ..."

Commissioner McGaffigan's statement is misleading on at least three counts:

(1) Current emergency planning guidance is already based on the principle that exposures of "a couple of rem" would be acceptable following a large radiological release;

(2) The potential doses from a large radiological release can greatly exceed "a few hundred millirem or even a couple of rem" far downwind of the release site, and for many individuals could result in a significant increase in their lifetime risk of cancer (10% or greater) or even pose a risk of severe injury or death from acute radiation exposure;

(3) Even if the average dose resulting from a large release were on the order of "a couple of rem," the total collective detriment (latent cancer fatalities and economic damages) could be very high if a large number of people in a densely populated area were so affected.

We believe that misinformation originating within NRC itself is the biggest obstacle to development of the robust radiological emergency planning strategies needed to cope with today's heightened threat. Statements like those cited above raise the concern that those responsible for regulating the nuclear industry and protecting it from terrorist attack are either in a chronic state of denial or actually believe the propaganda generated by the nuclear industry for public consumption. If this is indeed the case, then one cannot have confidence that emergency planning officials are basing their decisions on accurate and unbiased information. Since the departure of NRC Commissioner Greta Dicus a few years ago, the current Commission does not have any members with backgrounds in radiation protection and health issues. One wonders whether the NRC Commissioners truly understand and appreciate the full extent of the dangers posed by the facilities that they regulate.

(c) The CRAC2 Report

Given the lack of credible information from public officials on the potential consequences of a terrorist attack at Indian Point, concerned neighbors of the plant turned to one of the few sources on this subject in the public domain --- the so-called "CRAC2 Report," carried out by Sandia National Laboratories (SNL) under contract for NRC in 1981. This study, formally entitled "Technical Guidance for Siting Criteria Development," used a computer code developed by SNL known as CRAC2 ("Calculation of Reactor Accident Consequences") to analyze the consequences of severe nuclear plant accidents and to study their dependence on population density, meteorological conditions and other characteristics. The version of the CRAC2 Report that had been submitted to NRC for eventual public release only contained average values of consequence results,

but the "peak" values for worst-case weather conditions were obtained by Congressman Edward Markey in 1982 and provided to the Washington Post.[13]

At many reactor sites, the CRAC2 Report predicted that for unfavorable weather conditions, a severe nuclear reactor accident could cause tens of thousands of early fatalities as a result of severe radiation exposure, and comparable numbers of latent cancer fatalities from smaller exposures. For Indian Point 3 (which at the time operated at a significantly lower power than it now does), CRAC2 predicted peak values of 50,000 early fatalities and 14,000 latent cancer fatalities, with early fatalities occurring as far as 17.5 miles downwind of the site.

The CRAC2 Report only considered accidents affecting operating nuclear reactors, and did not evaluate the consequences of accidents also involving spent fuel storage pools. Spent fuel pool loss-of-coolant accidents could themselves result in large numbers of latent cancer fatalities, widespread radiological contamination and huge cleanup bills, even if only a fraction of the fuel in the pool were damaged.

The release of the CRAC2 figures caused a great deal of consternation, but NRC was able to defuse the controversy by claiming that the peak results corresponded to accidents with extremely low probabilities (said to be one in a billion), and hence were not a cause for concern. In fact, Robert Bernero, director of the NRC's risk analysis division at the time, said (in a moment of unfortunate prescience) that such severe accidents would be less likely than "a jumbo jet crashing into a football stadium during the Superbowl."[14]

When Riverkeeper and other groups dusted off and called attention to the CRAC2 Report following the September 11 attacks, the NRC appeared unable to appreciate the new relevance of the study in a world where the possibility of a jumbo jet crashing into the Superbowl was no longer so remote. For example, in rejecting a 2001 petition filed by Riverkeeper to shut down the Indian Point plant until Entergy implemented a number of prudent security-related measures, the NRC merely repeated its old probability-based arguments, saying that[15]

> "...the reactor siting studies in the CRAC2 Report ... used generic postulated releases of radioactivity from a spectrum of severe (core melt) accidents, independent of the probabilities of the event occurring or the impact of the mitigation mechanisms. The studies were never intended to be realistic assessments of accident consequences. The estimated deaths and injuries resulted from assuming the most adverse condition for each parameter in the analytical code. In the cited studies, the number of resulting deaths and injuries also reflected the assumption that no protective actions were taken for the first 24

[13] Subcommittee on Oversight & Investigations, Committee on Interior and Insular Affairs, U.S. House of Representatives, "Calculation of Reactor Accident Consequences (CRAC2) For U.S. Nuclear Power Plants Conditional on an 'SST1' Release," November 1, 1982.
[14] Robert J. McCloskey, "The Odds of the Worst Case," *Washington Post*, November 17, 1982.
[15] US Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Notice of Director's Decision Under 10 CFR 2.206, November 18, 2002.

hours. The studies did not, and were never intended to, reflect reality or serve as a basis for emergency planning. The CRAC2 Report analyses used more simplistic models than current technologies."

Earlier in 2002, in a letter to the New York City Council, the NRC also said that[16]

"The Sandia study does not factor in the numerous probabilistic risk studies that have been performed since 1982. More realistic, current inputs, assumptions, and modeling techniques would be expected to result in much smaller health consequences."

In a more recent "point paper" on homeland protection and preparedness, NRC continued to repeat these themes, although its conclusions were somewhat more equivocal: [17]

"The Sandia Siting Study ["CRAC2"] ... was performed to develop technical guidance to support the formulation of new regulations for siting nuclear power reactors. A very large radiation release and delayed evacuation, among other factors, accounts for the more severe consequences ... As an overall conclusion, that report does not present an up-to-date picture of risk at nuclear plants and does not reflect current knowledge in probabilistic or phenomenological modeling.

"Since September 11, 2001, the NRC has been performing assessments of the consequences of a terrorist attack on a nuclear power plant. These assessments are much more detailed than past analyses and reflect our improved understanding of severe accident phenomena. The more recent analyses have involved a more realistic assessment of the radiation release, emergency planning capabilities, radiation spreading, and health effects. More recent analysis indicates a general finding that public health effects from terrorist attacks at most sites are likely to be relatively small."

Although NRC continues to harshly criticize the CRAC2 Report and anyone who cites its results, it has not publicly identified the "more realistic, current inputs, assumptions and modeling techniques that would be expected to result in much smaller health consequences," much less demonstrated the validity of these results by providing the public with its calculations for independent review. In fact, NRC now considers that these analyses are too sensitive for public release, making it impossible for the public to verify its claims.

NRC's unwillingness to share this kind of information with the public is not unexpected. NRC (like its predecessor, the Atomic Energy Commission) has worked over its history to shield the public from estimates of the consequences of severe accidents without simultaneous consideration of the low probabilities of such accidents. By multiplying

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[16] Hubert Miller, Region I Administrator, US NRC, letter to Donna De Constanzo, Legislative Attorney, New York City Council, July 24, 2002.
[17] US Nuclear Regulatory Commission, "Point Paper on Current Homeland Protection and Preparedness Issues," November 2003, on the NRC Web site, www.nrc.gov.

high consequence values with very low probability numbers, the consequence figures appear less startling to the layman but are obscured in meaning. For instance, a release that could cause 100,000 cancer fatalities would only appear to cause 1 cancer fatality per year if the associated probability of the release were 1/100,000 per year.

This issue was central to the so-called Indian Point Special Proceeding, a 1983 review conducted by a panel of NRC administrative judges that examined whether Indian Point posed unusually high risks because of its location in the densely populated New York metropolitan area. Before this proceeding, the NRC ruled that all testimony on accident consequences must also contain a discussion of accident probabilities. However, in its decision, the three-judge Atomic Safety and Licensing Board panel concluded that "the Commission should not ignore the potential consequences of severe-consequence accidents by always multiplying those consequences by low probability values."[18] One of the judges dissented from this majority opinion, insisting that singling out Indian Point "to the exclusion of many other sites similarly situated in effect raises again the question of considering consequences without their associated probabilities. This we have been restricted from doing by the Commission."[19] Today, it appears that this minority opinion ultimately prevailed at NRC.

The results of the CRAC2 Report are indeed of questionable applicability today. But the reasons for this are not the ones that NRC has identified, but include, for example, the fact that the CRAC2 Report

- used census data from 1970, at a time before rampant suburban sprawl greatly increased the population densities in formerly rural areas close to some nuclear reactor sites;
- assumed that the entire 10-mile emergency planning zone would be completely evacuated within at most six hours after issuance of a warning (contrary to NRC's assertion that the CRAC2 peak results reflect the assumption that "no protective actions were taken for the first 24 hours"), whereas the current evacuation time estimate for the Indian Point EPZ, based on updated assessments of likely road congestion, is nearly ten hours;
- assumed aggressive medical treatment for all victims of acute radiation exposure in developing estimates of the number of early fatalities, and employed a now-obsolete correlation between radiation dose and cancer risk that underestimated the risk by a factor of 4 relative to current models;
- sampled only 100 weather sequences out of 8760 (an entire year's worth), a method which we find underestimates the peak value occurring over the course of a year by 30%.

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[18] US Nuclear Regulatory Commission, Atomic Safety and Licensing Board, Indian Point Special Proceeding, Recommendations to the Commission, October 24, 1983, p. 107.
[19] Ibid, "Dissenting Views of Judge Gleason," p. 433.

In 1990, the CRAC2 code was retired in favor of a new code known as MACCS ("MELCOR Accident Consequence Code System"), which was updated to MACCS2 in 1997. The MACCS2 code, also developed by Sandia National Laboratories, is the state-of-the-art consequence code employed by both NRC and DOE in conducting dose assessments of radiological releases to the atmosphere. It includes numerous improvements over the CRAC2 code.[20]

However, the fundamental physics models that form the basis for both the CRAC2 and MACCS2 codes have not changed in the past two decades. Nor has evidence arisen since the CRAC2 Report was issued that would suggest that the CRAC2 "source term" --- that is, the fraction of the radioactive contents of the reactor core assumed to be released to the environment during a severe accident --- significantly overestimated potential releases. On the contrary, the Chernobyl disaster in 1986 demonstrated that such large releases were possible.[21] The state-of-the art revised source term developed by NRC, as defined in the NRC report NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants," is little different from the source terms used in the CRAC2 Report.[22] Recent experimental work, including the Phébus tests in France, have provided further confirmation of the NUREG-1465 source term.[23] Other tests, such as the VERCORS experiments in France, have found that NUREG-1465 actually underestimates the releases of some significant radionuclides.

The NRC continues to stress the absence of consideration of accident probabilities in dismissing the results of the CRAC2 Report. However, this criticism is invalid in the post-9/11 era. Accident probabilities are not relevant for scenarios that are intentionally caused by sabotage. Severe releases resulting from the simultaneous failure of multiple safety systems, while very unlikely if left up to chance, are precisely the outcomes sought by terrorists seeking to maximize the impact of their attack. Thus the most unlikely accident sequences may well be the most likely sabotage sequences.

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[20] D.I. Chanin and M.L. Young, *Code Manual for MACCS2: Volume 1, User's Guide*, SAND97-0594, Sandia National Laboratories, March 1997.

[21] The nuclear industry often argues that a Chernobyl-type accident could not happen in the United States because the reactor was of a different and inferior type to US plants and lacked a robust containment structure. While it is true that the specific accident sequence that led to the destruction of the Chernobyl-4 reactor and the resulting radiological release was characteristic of graphite-moderated reactors like Chernobyl and would not likely occur at a US light-water reactor (LWR), it is simply false to claim that there are no possible accident sequences that could result in consequences similar to those of Chernobyl --- namely, core melt, loss or bypass of containment, and large radiological release to the environment. In fact, because such an event is not as likely to be as energetic as the Chernobyl explosion, and the plume is not likely to be as hot as the Chernobyl plume (which was fed by the burning of a large mass of graphite), the radiological release from a severe accident at a US LWR will not rise as high or disperse as far. Therefore, radiological exposure to the public near a US LWR could be far greater than was the case at Chernobyl, because the plume would be more concentrated closer to the plant.

[22] L. Soffer, et al., *Accident Source Terms for Light-Water Nuclear Power Plants, Final Report*, NUREG-1465, US NRC, February 1995.

[23] US NRC, Memorandum from Ashok Thadani to Samuel J. Collins, "Use of Results from Phébus-FP Tests to Validate Severe Accident Codes and the NRC's Revised Accident Source Term (NUREG-1465)," Research Information Letter RIL-0004, August 21, 2000.

Other aspects that add an element of randomness to accident scenarios, such as meteorological conditions, can also be controlled through the advance planning and timing of a terrorist attack. Therefore, even if NRC were correct in claiming that the CRAC2 Report assumes the "most adverse condition" for each accident-related parameter, such an approach would still be appropriate for analyzing the potential maximum consequences of a sophisticated terrorist attack.

We have not been able to identify any issues that would suggest the consequence estimates provided in the CRAC2 Report were significantly overstated. But in light of the problems with the CRAC2 Report discussed earlier, we have conducted our own analysis of the consequences of a sophisticated terrorist attack at the Indian Point plant, using the MACCS2 code and the most up-to-date information available. This included the NUREG-1465 revised source term, the most current dose conversion and cancer risk coefficients recommended by the International Commission on Radiological Protection (ICRP), and the most recent evacuation time estimate (ETE) for Indian Point developed by consultants for Entergy Nuclear, the plant operator. We used the SECPOP2000 code, developed for NRC by Sandia National Laboratories, to generate a high-resolution MACCS2 site data file that includes a regional population distribution based on 2000 Census data and an economic data distribution based on 1997 government statistics.

For Indian Point, we find that the MACCS2 results for peak early fatalities are generally consistent with the CRAC2 Report, but that the CRAC2 Report significantly underestimates the peak number of latent cancer fatalities that could occur.

Moreover, the consequence estimates in this report are based on a number of optimistic assumptions, or "conservatisms," that tend to underestimate the true consequences of a terrorist attack at Indian Point. For example:

1. We use an evacuation time estimate that assumes the attack takes place in the summer in good weather, and does not take into account the possibility that terrorists may time their attack when evacuation is more difficult or actively interfere with the evacuation.

2. We only consider the permanent resident population of the 10-mile plume exposure EPZ, and not the daily transient population, which would increase the total population of the EPZ by about 25%.

3. We use values for the rated power of the Indian Point reactors from 2002 that are about 5% lower than the current values.

4. The only health consequences we consider are early fatalities from acute radiation syndrome and latent fatalities from cancer. We do not assess the excess mortality associated with the occurrence of other well-documented health effects of radiation such as cardiovascular disease. We also do not consider non-fatal effects of radiation, such as the reduction in intelligence quotient (IQ) of children irradiated in utero or other birth defects.

5. The NUREG-1465 source term does not represent the maximum possible radiological release from a core melt. Also, the assumed delay time between the attack and the start of the radiological release is nearly two hours, which is not nearly as short as the minimum of 30 minutes that is contemplated in NRC's emergency planning regulations.

6. The calculations assume only that the reactors itself are attacked and that the large quantity of spent fuel in the wet storage pools remains undamaged.

In the following sections, we discuss some technical issues related to severe accident and sabotage phenomena. Then we describe the methodology, tools and input parameters used to carry out the calculation. Finally, we present our results and conclusions.

ACCIDENTS: DESIGN-BASIS, BEYOND-DESIGN-BASIS, AND DELIBERATE

The NRC has traditionally grouped nuclear reactor accidents into two main categories: "design-basis" accidents, and "beyond-design-basis" or "severe" accidents.

(a) Design-basis accidents

Design-basis accidents are accidents that nuclear plants must be able to withstand without experiencing unacceptable damage or resulting in radiological releases that exceed the regulatory limits known as "Part 100" releases (because of where they can be found in the NRC regulations).

One of the more challenging design-basis accidents for pressurized-water reactors (PWRs) like those at Indian Point is a loss-of-coolant accident (LOCA). In the "primary" system of a PWR, the reactor core, which is contained in a steel vessel, is directly cooled by the flow of high-pressure water forced through pipes. In a LOCA, a pipe break or other breach of the primary system results in a loss of the water essential for removing heat from the reactor fuel elements. Even if the nuclear reactor is immediately shut down or "scrammed," an enormous quantity of heat is still present in the fuel, and cooling water must be restored before a significant number of fuel elements reach temperatures above a critical limit. If heated beyond this limit, the fuel element cladding can become brittle and shatter upon contact with cooling water. Eventually, the core geometry can become "uncoolable" and the fuel pellets themselves will reach temperatures at which they start to melt.

In a design-basis LOCA, it is assumed that the emergency core cooling system (ECCS) works as designed to provide makeup coolant water to the nuclear fuel, terminating the event before it becomes impossible to control. Even in this case, however, a significant fraction of the radioactive inventory in the core could be released into the coolant and transported out of the primary system through the pipe break. The primary system therefore must be enclosed in a leak-tight containment building to ensure that Part 100 limits are not exceeded in the event of a design-basis LOCA. To demonstrate compliance with Part 100, dose calculations at the site boundary are carried out by specifying a so-called "source term" --- the radioactive contents of the gases within the containment following the LOCA --- and assuming that the containment building leaks at its maximum design leak rate, typically about 0.1% per day. Such an event was historically considered a "maximum credible accident."

(b) Beyond-design-basis accidents

In contrast to design-basis accidents, "beyond-design-basis" accidents (also known as "severe" accidents) are those in which multiple failures occur, backup safety systems do not work as designed, the core experiences a total "meltdown" and radiological releases far greater than the Part 100 limits become possible. For example, if the ECCS does not work properly after a LOCA, the core will continue to overheat, eventually forming a

molten mass that will breach the bottom of the steel reactor vessel and drop onto the containment floor. It will then react violently with any water that is present and with concrete and other materials in the containment. At this point, there is little hope that the event can be terminated before much of the radioactive material within the fuel is released in the form of gases and aerosols into the containment building.

Even worse is the potential for mechanisms such as steam or hydrogen explosions to rupture the containment building, releasing its radioactive contents into the environment. Although not the only distinguishing feature, a major distinction between design-basis and severe accidents is whether containment integrity is maintained. Even a small rupture in the containment building --- no more than a foot in diameter --- would be sufficient to depressurize it and to vent the gases and aerosols it contains into the environment in less than half an hour.[24] This would result in a catastrophic release of radioactivity on the scale of Chernobyl, and Part 100 radiation exposure limits would be greatly exceeded.

The containment building can also be "bypassed" if there is a rupture in one of the interfaces between the primary coolant system and other systems that are outside of containment, such as the "secondary" coolant system (the fluid that drives the turbine generators) or the low-pressure safety injection system. For instance, the rupture in the steam generator that occurred at Indian Point 2 in February 2000 created a pathway in which radioactive steam from the primary system was able to pass into the secondary system, which is not enclosed in a leak-tight boundary. If that event had coincided with significant fuel damage, the radiological release to the environment could have been far greater.

NRC has always had an uncomfortable relationship with beyond-design-basis accidents. By their very definition, they are accidents that were not considered in the original design basis for the plant. In fact, according to NRC, "the technical basis for containment design was intended to ensure very low leakage under postulated loss-of-coolant accidents. No explicit consideration was given to performance under severe accidents."[25] Indeed, NRC has never instituted a formal regulatory requirement that severe accidents be prevented. In 1985, the Commission ruled by fiat in its Severe Accident Policy Statement that "existing plants pose no undue risk to health and safety" and that no regulatory changes were required to reduce severe accident risk. NRC's basic assumption is that if a plant meets design basis requirements, then it will have sufficient resistance against severe accidents, and it has devoted considerable resources to the task of "confirmatory research" to justify this assumption. NRC believes that this approach provides "adequate protection" of public health and safety because the probability of a

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[24] US Nuclear Regulatory Commission, *Preliminary Assessment of Core Melt Accidents at the Zion and Indian Point Nuclear Power Plants and Strategies for Mitigating Their Effects, Analysis of Containment Building Failure Modes, Preliminary Report*, NUREG-0850, Vol. 1, November 1981, p. 3-2.
[25] US Nuclear Regulatory Commission, *Reactor Risk Reference Document (Appendices J-0)*, NUREG-1150, Draft for Comment, February 1987, p. J.10-1.

severe accident capable of rupturing or bypassing the containment prior to effective evacuation of the EPZ is so low in most cases as to be below regulatory concern.[26]

(c) "Deliberate accidents"

It is true that a spontaneous occurrence of the multiple system failures necessary to cause a severe accident and large radiological release is typically a very improbable event. However, if one considers the possibility of sabotage or "deliberate" accidents, the low-probability argument that NRC uses to justify the continued operation of nuclear plants completely breaks down. Terrorists with basic and readily available knowledge of how nuclear plants operate can design their attack to maximize the chance of achieving a core melt and large radiological release. With modest inside assistance, as contemplated by NRC in its regulations and practices, saboteurs would be able to identify a plant-specific set of components known as a "target set." If all elements of a target set are disabled or destroyed, significant core damage would result. Thus, by deliberately disrupting all redundant safety systems, saboteurs can cause a severe event that would have had only a very low probability of occurrence if left to chance.

The likelihood of a successful attack is enhanced for plants with "common-cause" failure modes. A common-cause failure is a single event that can lead to the failure of multiple redundant systems. For example, if the diesel fuel supplied to a nuclear plant with two independent emergency diesel generators from the same distributor is impure, then both generators may fail to start for the same reason if off-site power is lost and emergency power is needed. This would result in a station blackout, one of the most serious challenges to pressurized-water reactors like Indian Point. While some common-cause failure modes can be corrected, others are intrinsic to the design of currently operating nuclear plants. Common-cause failure modes make the saboteurs' job easier, as fewer targets would have to be disabled to achieve the desired goal.

In addition to causing a core meltdown, terrorists also have the means to ensure that the radioactive materials released from the melting fuel can escape into the environment by breaching, severely weakening or bypassing the containment.[27] Finally, saboteurs can maximize the harm caused by a radiological release by staging their attack when the meteorological conditions favor a significant dispersal over densely populated areas, and even interfering with the execution of emergency plans.

NRC has formally maintained for at least two decades that it does not make sense to assign probabilities to terrorist attacks. In a 2002 memorandum, NRC stated that[28]

> "the horrors of September 11 notwithstanding, it remains true that the likelihood of a terrorist attack being directed at a particular nuclear facility is not

[26] There have been situations where NRC concluded that "adequate protection" was not met at certain nuclear plants and required additional safety measures. However, such instances are rare.
[27] We have decided not to describe such means in greater detail, although we have little doubt that terrorists are already familiar with them.
[28] US NRC, Memorandum and Order, CLI-02-025, December 18, 2002, p. 17.

> quantifiable. Any attempt at quantification or even qualitative assessment would be highly speculative. In fact, the likelihood of attack cannot be ascertained with confidence by any state-of-the-art methodology ... we have no way to calculate the probability portion of the [risk] equation, except in such general terms as to be nearly meaningless."

Yet at other times, NRC does not hesitate to invoke probabilities when arguing that the public has nothing to fear from terrorist attacks on nuclear plants. For example, here is what NRC has to say about the CRAC2 study in its recent "point paper" on homeland protection and preparedness:[29]

> "Over the years, the NRC has performed a number of consequence evaluations to address regulatory issues ... We have considered the extent to which past analyses, often the subject of public statements by advocacy groups and the media, can be superceded [sic] by more recent analysis ... Past studies usually have considered ... a number of scenarios, which resulted in only minor consequences. The most limiting severe scenarios, which comprise a minority of the calculations and represent *very low probability events* [emphasis added], are the predictions typically cited in press accounts. These scenarios have assumed ... very large radiation releases, bounding emergency response assumptions or bounding conditions (including weather) for the spread of the radiation. The combination of these factors produces large and highly unlikely results."

These two excerpts are inconsistent. If it is meaningless to quantify the likelihood of a terrorist attack, then one cannot dismiss the possibility of terrorist attacks causing the most severe consequences by claiming they are "highly unlikely." Therefore, in order to base emergency planning on the best possible information, NRC must accept the fact that the growing threat of domestic terrorism has forever altered the delicate risk calculus that underlies its approach to safety regulation. NRC can no longer shy away from confronting the worst-case consequences of terrorist attacks on nuclear power plants. And perhaps the most attractive target in the country, where the consequences are likely to be the greatest, is Indian Point.

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[29] US NRC, "Point Paper on Current Homeland Protection and Preparedness Issues" (2003), op cit.

THE HEALTH CONSEQUENCES OF A RADIOLOGICAL RELEASE FROM INDIAN POINT

The Indian Point power plant is located on 239 acres on the Hudson River in the village of Buchanan in Westchester County, New York. There are two operating pressurized-water reactors (PWRs) on site, Indian Point 2, rated at 971 MWe, and Indian Point 3, rated at 984 MWe. Both reactors are operated by Entergy Nuclear.

Indian Point is located in one of the most densely populated metropolitan areas in the United States, situated about 24 miles from the New York City limits and 35 miles from midtown Manhattan. Extrapolating from 2000 Census data, in 2003 over 305,000 persons resided within the roughly ten-mile radius plume exposure emergency planning zone for Indian Point, and over 17 million lived within 50 miles of the site.[30]

The types of injury that may occur following a catastrophic release of radioactive material resulting from a terrorist attack at Indian Point fall into two broad categories. The first category, "early" injuries and fatalities, are those that are caused by short-term whole-body exposures to doses of radiation high enough to cause cell death. Early injuries include the constellation of symptoms known as **acute radiation syndrome** that should be familiar to anyone who has read *Hiroshima* by John Hersey --- gastrointestinal disturbance, epilation (hair loss) and bone marrow damage. Other early injuries include severe skin damage, cataracts and sterility. For sufficiently high doses, early fatalities --- death within days or weeks --- can occur. These so-called "deterministic" effects are induced only when levels of radiation exposure exceed certain thresholds.

Another class of injury caused by ionizing radiation exposure is genetic damage that is insufficient to cause cell death. At doses below the thresholds for deterministic effects, radiation may cause damage to DNA that interferes with the normal process of cell reproduction. This damage can eventually lead to cancer, which may not appear for years or even decades, depending on the type. Because a single radiation-induced DNA lesion is believed to be capable of progressing to cancer, there is no threshold for these so-called "stochastic" effects.[31]

The clinical response of individuals to ionizing radiation exposure is highly variable from person to person. Some individuals have a lower capability of DNA repair and thus are more susceptible to the carcinogenic effects of radiation --- a condition that is most severe in people with certain genetic diseases like ataxia telangiectasia. Children are particularly vulnerable to radiation exposure. For the same degree of exposure to a

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[30] A figure of 20 million people within 50 miles of Indian Point has often been quoted. This value may have been obtained by summing the populations of all counties that are either totally or partially within the 50-mile zone.

[31] A small but vocal group of pro-nuclear activists continue to maintain, in the face of overwhelming scientific evidence to the contrary, that a threshold dose exists below which ionizing radiation may have no effect or even may provide health benefits. However, there is a growing body of experimental data that indicates that low-dose radiation may actually be a more potent carcinogen than high-dose radiation because of low-dose "bystander effects."

radioactive plume, children will receive a greater absorbed dose than adults because of their lower body weight and higher respiration rate, even though their lung capacity is smaller. And because children and fetuses have much higher growth rates than adults, the same radiation dose has a greater chance of causing cancer in children and fetuses than in adults.

Exposure to low-dose ionizing radiation has also been associated with excess mortality from diseases other than cancer, such as cardiovascular disease, possibly as a result of radiation-induced inflammation. There is growing evidence that the effect of low-dose radiation exposure on mortality from diseases other than cancer may be as great as its effect on mortality from cancer, implying that current, cancer-based risk estimates may be too low by a factor of two.[32]

A radiological release from a nuclear plant accident would consist of many different types of radioactive materials. Some isotopes, such as cesium-137, emit penetrating gamma rays and can cause radiation injury from outside of the body. Other isotopes do not emit radiation that can penetrate skin but are most dangerous when inhaled or ingested, where they can concentrate in internal organs and deliver high doses to surrounding tissue. Iodine-131, which concentrates in the thyroid gland, and strontium-90, which concentrates in teeth and bones, are in this category. Some isotopes have short half-lives and do not persist in the environment, while others are long-lived and can result in long-term contamination.

NRC requires that evacuation planning in the event of a radiological emergency take place only within the so-called "plume exposure" emergency planning zone (EPZ), a roughly circular area with a radius of approximately ten miles. The choice of this distance was based in part on NRC analyses indicating that in the event of a severe accident, dose rates high enough to cause early fatalities from acute radiation syndrome would be confined to a region within about ten miles of the release point. However, dose rates outside of this region, although on average not high enough to cause early fatalities, could be high enough to result in a significant risk of cancer unless effective protective measures are taken. NRC's emergency planning regulations were never designed to limit such exposures in the event of the "worst core melt sequences," for which the protection goal is that "immediate life threatening doses would generally not occur outside the zone."[33]

Thus the current emergency planning basis is not now, and never was, intended to protect the public from significant but not immediately lethal exposures in the event of the "worst core melt sequences," such as those that could result from a well-planned terrorist attack. It should therefore be no surprise that NRC's emergency planning procedures

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[32] A. MacLachlan, "UNSCEAR Probes Low-Dose Radiation Link to Non-Cancer Death Rate," *Nucleonics Week*, June 17, 2004.
[33] US NRC, *Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Plants*, NUREG-0654, 1980, p. 12.

would not protect individuals either inside or outside the EPZ from such exposures in the event of an attack.

The proximity of Indian Point to New York City, its populous suburbs and its watershed, given the potential hazard it represents, has long been an issue of concern and controversy. Following the Three Mile Island accident in March 1979, the Union of Concerned Scientists (UCS) unsuccessfully petitioned the NRC to suspend operations at Indian Point, in part because of its location in a densely populated area. At the same time, the NRC formed two task forces to examine the risks posed by Indian Point and the Zion plant near Chicago "because of the high population densities surrounding those units" and initiated a formal adjudication, the Indian Point Special Proceeding, to review the issues raised in the UCS petition and others.[34]

During the Special Proceeding, three NRC administrative judges heard testimony regarding the potential impacts of a severe accident at Indian Point on New York City residents. For instance, the director of New York City's Bureau of Radiation Control testified that potassium iodide (KI), which can block the uptake of radioactive iodine by the thyroid if taken near the time of exposure, should be stockpiled for "possible immediate use in New York City," at a time when NRC did not recommend that KI be provided even for residents of the 10-mile EPZ.

The administrative judges reached some disturbing conclusions in the proceeding. They stated that "under certain meteorological conditions, delayed fatalities from cancer appear to be possible almost anywhere in the city" and that "a severe release at Indian Point could have more serious consequences than that same release at virtually any other site licensed by the Commission." And they urged the Commission "to give serious consideration to the potential costs to society of dangerous, low probability accidents. Such accidents could, as Staff testimony has shown, result in fatalities that number in the hundreds or thousands."

The Commission appears to have essentially forgotten these conclusions. Many of the technical issues resolved during the course of the Special Proceeding are being debated all over again today.

[34] US NRC, Indian Point Special Proceeding, 1983, p. 5.

THE MACCS2 CODE

MACCS2 is a computer code that was developed by Sandia National Laboratories under NRC sponsorship as a successor to CRAC2.[35] It is designed to estimate the health, environmental and economic consequences of radiation dispersal accidents, and is widely used by NRC and DOE for various safety applications. It utilizes a standard straight-line Gaussian plume model to estimate the atmospheric dispersion of a point release of radionuclides, consisting of up to four distinct plumes, and well-established models to predict the deposition of radioactive particles on the ground from both gravitational settling ("dry deposition") and precipitation ("wet deposition").[36] From the dispersion and deposition patterns, the code can then estimate the radiation doses to individuals as a result of external and inhalation exposures to the radioactive plume and to external radiation from radionuclides deposited on the ground ("groundshine"). The code also has the capability to model long-term exposures resulting from groundshine, food contamination, water contamination and inhalation of resuspended radioactive dust.

The code also can evaluate the impact of various protective actions on the health and environmental consequences of the release, including evacuation, sheltering and, in the long term, remediation or condemnation of contaminated areas. Most parameters, such as the average evacuation speed, decontamination costs, and the dose criteria for temporary relocation and long-term habitation, can be specified by the user.

MACCS2 requires a large number of user-specified input parameters. A given release is characterized by a "source term," which is defined by its radionuclide content, duration and heat content, among other factors. The shape of the Gaussian plume is determined by the wind speed, the release duration, the atmospheric stability (Pasquill) class and the height of the mixing layer at the time of the release.

MACCS2 requires the user to supply population and meteorological data, which can range from a uniform population density to a site-specific population distribution on a high-resolution polar grid. The meteorological data can range from constant weather conditions to a 120-hour weather sequence. The code can process up to 8760 weather sequences --- a year's worth --- and generate a frequency distribution of the results.

The code allows the user to define the dose-response models for early fatalities (EFs) and latent cancer fatalities (LCFs). We use the MACCS2 default models. For EFs, MACCS2 uses a 2-parameter hazard function, with a default LD_{50} dose (the dose associated with a 50% chance of death) of 380 rem. LCFs, MACCS2 uses the standard linear, no-threshold model, with a dose-response coefficient of 0.1 LCF/person-Sievert and a dose-dependent reduction factor of 2, per the 1991 recommendations of the International Committee on

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[35] Chanin and Young (1997), op cit.

[36] Much of the following section is based on a recent comprehensive review of MACCS2 by the Department of Energy, which we would recommend to readers interested in a more in-depth discussion of the capabilities and limitations of the code. See Office of Environment, Safety and Health, U.S. Department of Energy, *MACCS2 Computer Code Application Guidance for Documented Safety Analysis: Interim Report*, DOE-EH-4.2.1.4-Interim-MACCS2, September 2003.

Radiological Protection (ICRP) in ICRP 60.[37] The corresponding coefficients used in the CRAC2 model, based on now-antiquated estimates, were lower by a factor of 4.

For the calculation of the committed effective dose equivalent (CEDE) resulting from inhalation and ingestion of radionuclides, we have replaced the default MACCS2 input file with one based on the more recent dose conversion factors in ICRP 72.[38] We have shown previously that this substitution reduces the projected number of latent cancer fatalities from a severe nuclear reactor accident by about one-third.[39] (The default MACCS2 file incorporates EPA guidance based on ICRP 30, which although out of date continues to be the basis for regulatory analyses in the United States.)

When using MACCS2 several years ago, we discovered an error that resulted in an overcounting of latent cancer fatalities in the case of very large releases. After pointing this out to the code manager, SNL sent us a revised version of the code with the error corrected, which we have used for the analysis in this report.

Like most radiological consequence codes in common use, MACCS2 has a number of limitations. First of all, because it incorporates a Gaussian plume model, the speed and direction of the plume are determined by the initial wind speed and direction at the time of release, and cannot change in response to changing atmospheric conditions (either in time or in space). Consequently, the code becomes less reliable when predicting dispersion patterns over long distances and long time periods, given the increasing likelihood of wind shifts. Also, the Gaussian plume model does not take into account terrain effects, which can have a highly complex impact on wind field patterns and plume dispersion. And finally, MACCS2 cannot be used for estimating dispersion less than 100 meters from the source.

However, MACCS2 is adequate for the purpose of this report, which is to develop order-of-magnitude estimates of the radiological consequences of a catastrophic attack at Indian Point for residents of New York City and the entire New York metropolitan area, and to assess the impact of different protective actions on these consequences. We restrict our evaluations to a circular area with a radius of 50 miles centered on Indian Point, except for the calculation of long-term doses and economic impacts, which we assess out to 100 miles.

In the next section, we discuss the basis for the MACCS2 input parameters that we use in our evaluation.

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[37] MACCS2 does not allow the user to specify different dose-response models for different radionuclides. We use a model with a dose-dependent reduction factor of 2, even though this assumption likely underestimates the carcinogenic potential of alpha-emitters, which is not reduced in effectiveness at low doses or dose rates.

[38] International Commission on Radiological Protection (ICRP), *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5, Compilation of Ingestion and Inhalation Dose Coefficients*, ICRP Publication 72, Pergamon Press, Oxford, 1996.

[39] E. Lyman, "Public Health Risks of Substituting Mixed-Oxide for Uranium Fuel in Pressurized-Water Reactors," *Science and Global Security* 9 (2001), pgs. 33-79. See Footnote 48.

THE SABOTAGE SCENARIO

The scenario that we analyze is based on the so-called "revised source term" that NRC defined in 1995 in NUREG-1465. The revised source term was developed as a more realistic characterization of the magnitude and timing of radionuclide releases during a core-melt accident than the source term originally specified for use in Part 100 siting analyses. In its entirety, the PWR revised source term presented in NUREG-1465 corresponds to a severe accident in which the primary coolant system is depressurized early in the accident sequence. An example is a "large break loss-of-coolant accident" (LBLOCA), in which primary coolant is rapidly lost and the low-pressure safety injection system fails to operate properly, resulting in core melt and vessel failure. This scenario is one of the most severe events that can occur at PWRs like Indian Point, and could result in a relatively rapid release of radioactivity.

(a) The source term

A severe accident of this type would progress through four distinct phases. As the water level in the core decreases and the fuel becomes uncovered, the zirconium cladding tubes encasing the fuel rods overheat, swell, oxidize and rupture. When that occurs, radionuclides that have accumulated in the "gap" between the fuel and the cladding will be released into the reactor coolant system. If there is a break in the reactor coolant system (as would be the case in a LBLOCA), then these radionuclides would be released into the atmosphere of the containment building. These so-called "gap" releases consist of the more volatile radionuclides contained in irradiated fuel, such as isotopes of krypton, xenon, iodine and cesium. This period is known as the "gap release" phase, and is predicted to last about 30 minutes. The oxidation of the zirconium cladding by water also generates hydrogen, which is a flammable gas.

As the core continues to heat up, the ceramic fuel pellets themselves begin to melt, releasing greater quantities of radionuclides into the reactor vessel and through the breach in the reactor coolant system into the containment building atmosphere. The molten fuel mass then collapses and drops to the bottom of the reactor vessel, where it aggressively attacks the steel, melts through the bottom and spills onto the floor of the containment building.[40] The period between the start of fuel melting and breach of the reactor vessel is known as the "early in-vessel" phase, and typically would last about an hour.

When the molten fuel breaches the reactor vessel and drops to the containment building floor, it violently reacts with any water that has accumulated in the cavity and with the concrete floor itself. This "core-concrete interaction" causes further releases of radionuclides from the molten fuel into the containment building. This period is known as the "ex-vessel" phase, and would last for several hours.

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[40] This scenario is not theoretical. During the 1979 accident at Three Mile Island Unit 2, part of the melted core relocated to the bottom of the reactor vessel where it began melting through the steel. The re-introduction of forced cooling water flow terminated this sequence before vessel failure.

At the same time, some portion of the molten core may remain in the reactor vessel, where it would continue to degrade in the presence of air and release radionuclides. Also, radionuclides released during the in-vessel phase that deposit on structures within the primary coolant system may be re-released into the containment building. These releases take place during the "late in-vessel" phase and could continue for many hours.

At the time when the molten core falls to the floor of the reactor vessel, steam explosions may occur that could blow apart the reactor vessel, creating high-velocity "missiles" that could rupture the containment building and violently expel the radioactive gases and aerosols it contains into the environment. This would result in a shorter in-vessel phase. If the vessel remains intact until melt-through, hydrogen or steam explosions are also possible when the molten fuel spills onto the concrete below the vessel, providing another opportunity for containment failure.

The complete revised source term (all four phases) is a general characterization of a low-pressure severe accident sequence, such as a large-break loss of coolant accident with failure of emergency core cooling systems. According to the timing of the accident phases in the revised source term, the "gap release" phase would begin within a few minutes after the initiation of the event and lasts for 30 minutes. At that time, the early in-vessel phase begins as the fuel pellets start to melt. This phase is assumed to last for 1.3 hours, and ends when the vessel is breached.

In our scenario, we assume that the attackers have weakened but not fully breached the containment, so that there is a high probability that the containment building will be ruptured by a steam or hydrogen explosion at the time of vessel breach. This results in a rapid purge of the radionuclide content of the containment building atmosphere into the environment, followed by a longer-duration release due to core-concrete interactions and late in-vessel releases.

We do not wish to discuss in detail how saboteurs could initiate this type of accident sequence. However, since NRC asserts that even in a terrorist attack these events are unlikely to occur, we need to present some evidence of the plausibility of these scenarios. One such scenario would involve a 9/11-type jet aircraft attack on the containment building, possibly accompanied by a ground attack on the on-site emergency power supplies. (One must also assume that interruption of off-site power takes place during an attack, given that off-site power lines are not under the control of the licensee and are not protected.)

The Nuclear Energy Institute (NEI) issued a press release in 2002 describing some of the conclusions of a study conducted by the Electric Power Research Institute (EPRI) that purported to show that penetration of a PWR containment by a jet aircraft attack was impossible. A study participant later acknowledged that (1) the justification for limiting the impact speed to 350 mph was based on pilot interviews and not on the results of simulator testing, and (2) even at 350 mph, their analysis actually found that the 42-inch

thick reinforced concrete containment dome of a PWR suffered "substantial damage" and the steel liner was deformed.[41]

However, even if penetration of the containment does not occur, the vibrations induced by the impact could well disrupt the supports of the coolant pumps or the steam generators, causing a LBLOCA. The emergency core cooling system pumps, which require electrical power, would not be available under blackout conditions caused by the disabling of both off-site and on-site power supplies. Thus makeup coolant would not be provided, the core would rapidly become uncovered and the NUREG-1465 sequence would begin. Other engineered safety features such as containment sprays and recirculation cooling would not be available in the absence of electrical power. The damaged containment building would then be far less resistant to the pressure pulse caused by a steam spike or hydrogen explosion, and would have a much higher probability of rupture at vessel breach. We note that the steel liner of a reinforced concrete containment structure like that at Indian Point only carries 10 to 20% of the internal pressure load, and therefore may fail well before the design containment failure pressure is reached if the concrete shell is damaged.

Because the emergency diesel generators are themselves quite sensitive to vibration, a ground assault may not even be necessary to disable them, since the aircraft impact itself, followed by a fuel-air explosion, could cause them to fail.

One can find support for the credibility of this scenario in the recently leaked summary of a report prepared for the German Environment Ministry by the nuclear safety consultant GRS on the vulnerability of German nuclear reactors to aircraft attacks.[42] In the summary, GRS defined a series of credible damage scenarios and then determined whether or not the resulting accident sequence would be controllable The report considered an attack on the Biblis B PWR by a small jet (Airbus A320) or medium-sized jet (Airbus A300) travelling at speeds from 225 to 394 miles per hour, where the peak speed of 394 mph was determined through the use of simulators. GRS concluded that for an event in which the jet did not penetrate the containment, but the resulting vibrations caused a primary coolant leak, and the control room was destroyed by debris and fire (a condition similar to a station blackout), then control of the sequence of events would be "uncertain."[43] Biblis B was designed for protection against the crash of a 1960s-era Starfighter jet and as a result is equipped, like most German reactors, with a double containment. In contrast, Indian Point 2 and 3, while of the same 1970s vintage as Biblis B, were not designed to be resistant to airplane crashes, and do not have double containments.

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[41] R. Nickell, "Nuclear Plant Structures: Resistance to Aircraft Impact," 44th Annual Meeting of the Institute of Nuclear Materials Management, Phoenix, AZ, July 13-17, 2003.
[42] Mark Hibbs, "Utilities Expect Showdown with Trittin over Air Terror Threat," *Nucleonics Week* **45**, February 12, 2004.
[43] Gesellschaft für Anlagen und Reaktorsicherheit, *Schutz der deutschen Kernkraftwerke vor dem Hintergrund der terroristischen Anschläge in den USA vom 11. September 2001*, (*Protection of German Nuclear Power Plants in the Context of the September 11, 2001 Terrorist Attacks in the US*), November 27, 2002.

The NUREG-1465 revised source term is shown in Table 1. The source term is characterized by grouping together fission products with similar chemical properties and for each group specifying a "release fraction"; that is, the fraction of the core radionuclide inventory released from the damaged fuel into the containment building atmosphere. Noble gases include krypton (Kr); halogens include iodine (I); alkali metals include cesium (Cs); noble metals include ruthenium (Ru); the cerium (Ce) group includes actinides such as plutonium (Pu) and the lanthanide (La) group includes actinides such as curium (Cm).

TABLE 1: NUREG-1465 radionuclide releases into containment for PWRs

	Gap	Early In-Vessel	Ex-Vessel	Late In-Vessel
Duration (hrs)	0.5	1.3	2.0	10.0
Release fractions (%):				
Noble Gases (Kr)	0.05	0.95	0	0
Halogens (I)	0.05	0.35	0.25	0.1
Alkali Metals (Cs)	0.05	0.25	0.35	0.1
Tellurium group (Te)	0	0.05	0.25	0.005
Barium, Strontium (Ba, Sr)	0	0.02	0.1	0
Noble Metals (Ru)	0	0.0025	0.0025	0
Cerium group (Ce)	0	0.0005	0.005	0
Lanthanides (La)	0	0.0002	0.005	0

It is important to note that NUREG-1465 is not intended to be a "worst-case" source term. The accompanying guidance specifically states that "it is emphasized that the release fractions for the source terms presented in this report are intended to be representative or typical, rather than conservative or bounding values…"[44] In fact, the release fractions for tellurium, the cerium group and the lanthanides were significantly lowered in response to industry comments. Upper-bound estimates, which are provided in a table in the back of NUREG-1465, indicate that "virtually all the iodine and cesium could enter the containment."[45] And experimental evidence obtained since NUREG-1465 was published in 1995 suggests that the tellurium, ruthenium, cerium and lanthanide release fractions in the revised source term may significantly underestimate actual releases of these radionuclide groups.[46] Thus our use of the NUREG-1465 source term is far from the worst possible case and may underestimate the impacts of credible scenarios.

[44] NUREG-1465, p. 13.
[45] NUREG-1465, p. 17.
[46] Energy Research, Inc., Expert Panel Report on Source Terms for High-Burnup and MOX Fuels, 2002.

We model this scenario in MACCS2 as a two-plume release. The first release begins at the time of vessel breach and containment failure, 1.8 hours after initiation of the accident, and continues over a period of 200 seconds as the containment atmosphere is rapidly vented. The second plume lasts for two hours as core-concrete interactions occur. For simplicity, only the first two hours of the late in-vessel release are included; the last eight hours are omitted, although this late release would likely make a significant contribution to public exposures, given the nearly ten-hour evacuation time estimate for the 10-mile EPZ.

We further assume that the entire radionuclide inventory released from the damaged fuel into the containment atmosphere escapes into the environment through the rupture in the containment. There is little information in the literature about realistic values for the fraction of the containment inventory that is released to the environment. In NUREG-1150, NRC states that "in some early failure cases, the [containment to environment] transmission fraction is quite high for the entire range of uncertainty. In an early containment failure case for the Sequoyah plant ... the fractional release of radioactive material ranges from 25 percent to 90 percent of the material released from the reactor coolant system."[47] A review of the default values of this fraction for the Sequoyah and Surry plants used in supporting analyses for NUREG-1150 indicates that environmental releases ranging from 80 to 98% of the radionuclides in the containment atmosphere were typically assumed. The only case in which significant retention within the containment building occurs is when there is a delay of several hours between the initiation of core degradation and the time of containment failure, which is not the case for the scenario we are considering. Given that we are using only the first three phases of the NUREG-1465 source term, which may underestimate the maximum release of radionuclides like iodine and cesium by 35%, we believe it is reasonable to neglect the retention within the containment building of at most 20% of the radionuclide inventory.

Another plume characteristic that is very important for determining the distribution and magnitude of consequences is the heat energy that it contains. The oxidation of zirconium cladding during core degradation generates a large amount of heat in a short period of time, which can cause the plume to become buoyant and rise. Greater initial plume heights result in lower radionuclide concentrations close to the plant, but wider dispersal of the plume.

It is unlikely that a radiological release at any US PWR would produce a plume as high as the one released during the Chernobyl disaster. Because of the large mass of graphite moderator in the Chernobyl-4 reactor, a hot and long-duration graphite fire caused a very high plume that was responsible for dispersing radionuclides over vast distances. However, at the same time, the exposure and contamination within 50 miles of the Chernobyl site was much lower than it would have been if the plume had not risen so high. This means that the cooler plume that would be characteristic of a core meltdown at Indian Point could actually be a greater threat to the New York metropolitan area than the contamination pattern resulting from the Chernobyl accident might suggest.

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[47] US NRC, *Severe Accident Risks: An Assessment for Five Nuclear Power Plants*, NUREG-1150, Volume 2, December 1990, p. C-108.

Table 2 shows the two-plume source term for input into MACCS2, adapted from the NUREG-1465 source term in Table 1. The first plume consists of the containment radionuclide inventory at the time of vessel breach (the sum of the first and second columns in Table 1). The second plume consists of the releases generated by core-concrete interactions and a fraction of the late-in-vessel releases (the sum of the third column and one-fifth of the fourth column in Table 1).

TABLE 2: Source term used in MACCS2 model

Plume	Release time (hrs)	Duration(hrs)	Energy release (MW)	Kr	I	Cs	Te	Ba	Ru	Ce	La
1	1.8	0.06	2.8	1	0.4	0.3	0.05	0.02	0.0025	0.0005	0.0002
2	1.86	2	1.6	0	0.27	0.37	0.25	0.1	0.0025	0.005	0.005

The reactor core inventory used was calculated for a representative 3565 MWt PWR at the end of an equilibrium 18-month cycle using the SCALE code, and was then scaled to the Indian Point 2 power rating of 3071 MWt.[48] Since Indian Point 2 operates on a 24-month cycle, the inventory we use here does not represent the peak inventory of the reactor core, which occurs just before refueling.

(b) Meteorology

The calculation of radiological consequences from a severe accident is strongly dependent on the meteorological conditions at the time of the release and for several days afterward. Relevant factors include the wind speed, the wind direction, the atmospheric stability, the height of the mixing layer and the occurrence of precipitation.

The MACCS2 code can utilize a weather sequence of hourly data for a 120-hour period following the initial release. The user has the option to supply a file with an entire year's worth of hourly meteorological data (8760 entries), consisting of wind speed, atmospheric stability class, and precipitation. The program can then calculate up to 8760 results, each corresponding to a release beginning at a different hour of the year. For each set of weather data, MACCS2 can also generate sixteen results by rotating the plume direction into each sector of the compass, repeating the calculation for each plume direction, and then weighting the results with the fraction of the time that the wind blows in that direction (as specified by the user-supplied "wind rose," or set of probabilities that the wind will be blowing in a certain direction at the site). Finally, the code can tabulate the results in a frequency distribution.

[48] Lyman (2001), op cit., pp. 64-66.

The MACCS2 code, like the CRAC2 code before it, has the option to sample a reduced number of weather sequences, based on a semi-random sampling method. The reason for employing a sampling scheme in the past was no doubt the length of computing time needed for each calculation; however, the program runs quickly on modern machines, so there is no need to employ the MACCS2 sampling scheme. In fact, a comparison of the results obtained from sampling, which utilizes about 100 weather sequences, and the results obtained from an entire year's worth of sequences, finds that the peak consequence values in the sampling distribution are 30% or more below the peak consequences over the entire year, if the plume rotation option is not utilized. Thus there is a significant sampling error for peak values associated with the MACCS2 sampling scheme (and presumably the CRAC2 sampling scheme as well).

We were unable to obtain the meteorological data for the Indian Point site needed for input into MACCS2. Instead, we used a meteorological data file for New York City, the location of the nearest National Weather Service weather monitoring station, that was supplied with the original CRAC2 code. This is the same approach that was taken in the CRAC2 Report, which was ostensibly a site-specific study of the 91 sites where nuclear reactors were located or planned, but did not use meteorological data files specific to those sites. Instead, the study used data derived from 29 National Weather Service stations that were "chosen as a representative set of the nation's meteorological conditions."[49] NRC later had to adopt the same approach, using the New York City meteorological data file as a surrogate for Indian Point-specific data in a CRAC2 benchmark exercise, because it was unable to obtain the Indian Point data.[50]

Use of the New York City meteorological data file in lieu of Indian Point site data is a reasonable approximation for the purposes of this report. Two of the most important factors in determining the radiological consequences of a terrorist attack at Indian Point are the wind direction and the precipitation. With regard to the first factor, we use the Indian Point site wind rose to take into account the effect of the variation in wind direction.[51] With regard to precipitation data, since the MACCS2 code only allows for uniform precipitation over the entire evaluation area, the precipitation data set from New York City is just as relevant as data from the Indian Point site for determining the consequences for the New York metropolitan area.

One phenomenon that we cannot fully account for without access to meteorological data specific to the Indian Point site is the coupling between wind direction and wind speed that results from the plant's location in the Hudson River Valley. Wind speeds below a threshold of below 4 meters per second tend to result in plumes that follow the course of the river valley, whereas greater wind speeds produce plumes that are free to travel in any direction and are better approximated by the straight-line Gaussian model. Our use of the

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[49] R. Davis, A. Hanson, V. Mubayi and H. Nourbakhsh, *Reassessment of Selected Factors Affecting Siting of Nuclear Power Plants*, NUREG/CR-6295, US Nuclear Regulatory Commission, 1997, p. 3-30.
[50] US Nuclear Regulatory Commission, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437, Vol. 1, Sec. 5.3.3.2.3.
[51] James Lee Witt Associates, *Review of Emergency Preparedness of Areas Adjacent to Indian Point and Millstone*, March 2003, Figure 3-1, p. 21.

Indian Point wind rose accounts for this effect, but to the extent that the distribution of wind speeds in the meteorological data file that we use differs from that at the Indian Point site, the calculations may include some cases that involve unrealistic wind patterns. However, any errors in the distribution resulting from this approximation are not likely to be significant in comparison to the uncertainties associated with use of the straight-line Gaussian model in MACCS2. In any event, it is likely that properly accounting for this effect would result in the channeling of a greater number of slow-moving, concentrated plumes directly downriver toward densely populated Manhattan, thereby increasing the overall radiological impact.

We have also run the calculations using the meteorological data file for the Surry site in Virginia to compare the maximum consequences obtained. We find that the values for peak early fatalities differ by less than 1% and the value for peak latent cancer fatalities differs by less than 5%. We interpret this result as an indication that the peak consequences we found for Indian Point are not due to weather conditions unique to the meteorological data file for New York City.

If Entergy were willing to provide us with data from the Indian Point meteorological monitoring station, we would be pleased to use it to assess whether it would have a significant impact on our results. However, we would expect any impact to be minor.

(c) Protective actions

Another crucial factor in determining the consequences associated with a terrorist attack at Indian Point is the effectiveness of the actions taken to protect individuals within the 10-mile emergency planning zone (EPZ).

The MACCS2 emergency planning model requires the user to input the time when notification is given to emergency response officials to initiate protective actions for the surrounding population; the time at which evacuation begins after notification is received; and the effective evacuation speed. Once evacuation begins, each individual then proceeds in a direction radially outward from the release point at a rate given by the effective evacuation speed.

We have assumed that the time at which the off-site alarm is sounded is coincident with the initiation of core melting; that is, 30 minutes after the attack. It is unlikely that the decision to evacuate could be made in much less time. This choice still provides an interval of 78 minutes between the sounding of the alarm and the initiation of the radiological release, consistent with earlier studies such as the CRAC2 Report.

We have assumed that the delay time between receipt of notification by the public within the EPZ and initiation of evacuation is two hours. This is the default parameter in the MACCS2 code, and is consistent both with earlier estimates of the "mobilization time" and with the most recent ones for the Indian Point site, which found that 100% of the public within the EPZ would be mobilized to evacuate by two hours after notification.[52]

[52] James Lee Witt Associates (2003), op cit., Figure 5-6, p. 96.

The effective evacuation speed was obtained from the mobilization time estimate of two hours and the most recent Indian Point evacuation time estimate (ETE) for good summer weather of 9 hours 25 minutes.[53] Subtracting the two-hour mobilization time leaves a maximum time of 7.42 hours for the actual evacuation. Since the maximum travel distance to leave the EPZ is approximately ten miles, this corresponds to an effective evacuation speed of 1.35 miles per hour, or 0.6 meters per second. The high value for the ETE and the correspondingly low effective evacuation speed reflect the severe traffic congestion within the EPZ that is projected to occur in the event that a crisis occurs at Indian Point requiring evacuation.

Outside of the 10-mile EPZ, the baseline dose calculations assume that individuals will take no protective actions.[54] Although this may not be realistic, we believe that it would be inappropriate to assume otherwise. Since NRC and FEMA do not require that any preparation for an emergency be undertaken outside of the 10-mile EPZ, it would not be conservative to assume that individuals outside of the EPZ would receive prompt notification of the event or would know what to do even if they did receive notification. However, to examine the impact of this assumption on the results, we consider a case where the emergency evacuation zone is extended to 25 miles, and the average evacuation speed remains the same as in the 10-mile EPZ case.

(d) Population distribution

In order to accurately calculate the consequences of a terrorist attack at Indian Point, it is necessary to have the correct spatial distribution of population in the vicinity of the site. MACCS2 has the option to use a site population data file, in which the site-specific population is provided on a grid divided into sixteen angular sectors. The user can specify the lengths of sectors in the radial direction.

Most of our analysis is focused on a circular region centered on the Indian Point site with a radius of fifty miles. The ten-mile EPZ is divided into eleven regions, with divisions at the site exclusion zone (about 0.5 miles), at the one-mile point, and nine successive mile-wide intervals. The region between the EPZ and the fifty-mile limit is subdivided into ten intervals (see Figure 1, below).

Permanent resident population data for the ten-mile EPZ was obtained from the estimates for 2003 generated by KLD Associates for the Evacuation Time Estimate study that it prepared for Entergy.[55] The total number of permanent residents within a ten-mile circular zone around Indian Point in 2003, according to KLD, was 267,099. We have not included the transient population in the region in our calculations, even though it would add another 25% to the permanent population estimate, according to KLD data.

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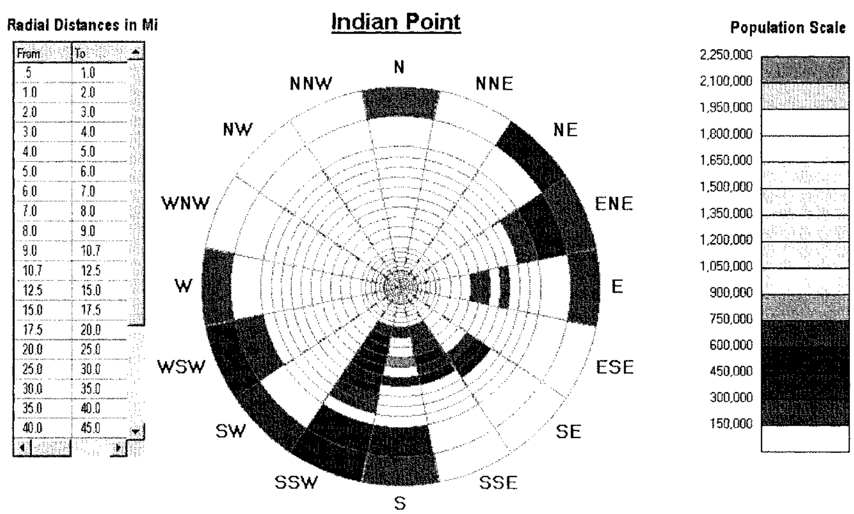
[53] KLD Associates, Inc., *Indian Point Energy Center Evacuation Time Estimate*, Rev. 0 (2003), p. 7-8.
[54] However, the calculation of doses within the EPZ does reflect the impact of "shadow evacuation" of individuals outside of the EPZ, since it uses the KLD Associates evacuation time estimate for the EPZ, which assumes that shadow evacuation occurs.
[55] KLD Associates, Inc. (2003), op cit., p. 3-7.

For the region from 10 to 100 miles from Indian Point, the MACCS2 site data file was generated with the SECPOP2000 code, which is the most recent version of the SECPOP code originally developed by the Environmental Protection Agency and later adopted by NRC for use in regulatory applications.[56] SECPOP2000 utilizes 2000 US Census data to estimate population distributions on a user-specified grid surrounding any location in the United States, drawing on a high-resolution database of over eight million census-blocks. By utilizing the 2000 Census data in SECPOP2000, we have slightly underestimated the population in this region, which appears to have increased by about 1% between 2000 and 2003.

The Indian Point plume exposure EPZ is not in the shape of a perfect circle of ten-mile radius, but includes some regions that are beyond ten miles from the plant. To account for the 38,177 individuals that reside within the EPZ but outside of the 10-mile circular zone (according to KLD estimates for 2003), we used the SECPOP2000 code to determine that an "effective" circular EPZ boundary of 10.68 miles would include the appropriate additional number of permanent residents, and adjusted the MACCS2 grid accordingly.

Figure 1 displays the population rosette generated by SECPOP2000 for Indian Point, out to a distance of 100 miles. The location of New York City is plainly visible on the grid.

FIGURE 1



[56] N. Bixler et al., *SECPOP2000: Sector Population, Land Fraction, and Economic Estimation Program*, NUREG/CR-6525, Rev. 1, Sandia National Laboratories, August 2003.

RESULTS

In this section, we present the results of the MACCS2 simulation of a terrorist attack at IP2, as previously described.

MACCS2 generates results for two distinct periods following a radiological release. First, it calculates the doses to individuals received during the "emergency" phase of the event, defined as the period extending up to the first week following the release. The doses received during this period result from direct exposure to and inhalation of the plume, as well as exposure to plume particles deposited on the ground ("groundshine"). Second, it separately calculates doses received beyond the first week after the release as a result of groundshine, inhalation of resuspended particles, and consumption of contaminated food and water. The first sets of results provided below refer only to the consequences of exposures received during a one-week emergency phase. The economic and long-term health consequences are calculated based on the evaluation of chronic exposures for a period of fifty years following the release, which are dominated by groundshine.

Following the format of the CRAC2 Report summary, our calculation considers several public health and environmental endpoints, including early fatalities, latent cancer fatalities, maximum distance for early fatalities, and total economic costs. The calculations were carried out for each of the 8760 weather sequences in the New York City meteorological data file by rotating the plume direction into each of the 16 sectors of the compass, and then generating a weighted average of the results according to the Indian Point site wind rose. For each endpoint, in addition to the mean of the distribution and the peak value corresponding to the worst-case meteorological conditions encountered during the year, we present the 95^{th} and 99.5^{th} percentile values of the distribution.

The results of the MACCS2 frequency distribution are based on the assumption that the radiological release would occur at random during the year, even though the timing of a terrorist attack most likely would be far from random. As we have previously discussed, one must assume that a terrorist attack intended to cause the maximum number of casualties would be timed to coincide as closely as possible with the most favorable weather conditions. In the case of Indian Point, an attack at night --- the time when a terrorist attack is most likely to be successful --- also happens to be the time when the prevailing winds are blowing toward New York City. Consequently, the mean and other statistical parameters derived from a random distribution are not characteristics of the actual distribution of consequences resulting from a terrorist attack, which would be restricted to a much more limited set of potential release times. A meteorological data set confined to the evening hours would skew the distribution in the direction of increased consequences.

In our judgment, the 95^{th} percentile values of these distributions, rather than the mean values, are reasonable representations of the likely outcome of a well-planned terrorist attack. This choice reflects the fact that the attack time will be largely of the terrorists' choosing, but that some factors will necessarily remain out of their control --- for instance,

the ability to accurately predict precipitation patterns, and the ability to launch an attack exactly as planned.

In the following tables, it is important to note that the peak results in each category do not correspond in general to the same weather sequence. For example, the weather conditions that lead to the maximum number of early fatalities are typically those that involve rainout and substantial deposition of the plume close to the plant, and thus are not the same conditions that lead to peak latent cancer fatalities, which involve rainout of the plume over New York City.

(a) Consequences of radiological exposures during "emergency phase"

Here we consider the consequences of exposures received during the 7-day "emergency phase." We calculate the number of "early fatalities" (EFs) resulting from acute radiation syndrome, both for the residents of the 10-mile EPZ, who are assumed to evacuate according to the scheme described previously, and for the entire population within 50 miles of the plant. Following the CRAC2 Report, we also provide the "early fatality distance," that is, the greatest distance from the Indian Point site at which early fatalities may occur. Finally, we provide an estimate of the number of latent cancer fatalities (LCFs) that will occur over the lifetimes of those who are exposed to doses that are not immediately life-threatening, both for residents of the EPZ and for residents of the 50-mile region.

It is important to note that these estimates are based on dose conversion factors (the radiation doses resulting from internal exposure to unit quantities of radioactive isotopes) appropriate for a uniform population of adults, and do not account for population variations such as age-specific differences. A calculation fully accounting for individual variability of response to radiation exposure is beyond the capability of the MACCS2 code and the scope of this report.

In Table 3, these results are provided for the case in which 100% evacuation of the EPZ occurs, based on the KLD evacuation time estimate and 2-hour mobilization time discussed earlier. Table 4 presents the same information for the case where the EPZ population is sheltered for 24 hours prior to evacuation. Finally, Table 5 presents the results for the extreme case where no special precautions are taken in the EPZ.

In interpreting the results of these tables, one should keep in mind that the MACCS2 code uses different radiation shielding factors for individuals that are evacuating, sheltering or engaged in normal activity. The default MACCS2 parameters (which we adopt in this study) assume that evacuees are not shielded from the radioactive plume by structures, since they are mostly outdoors or in non-airtight vehicles during the evacuation. Individuals who shelter themselves instead of evacuating are shielded to a considerable extent by structures, but may be exposed to higher levels of radiation overall because they remain in areas closer to the site of plume release. The MACCS2 default shielding parameters assume that sheltering reduces doses from direct plume exposure by 40% and doses from plume inhalation by 67%. The relative benefits of sheltering versus

evacuation are obviously quite sensitive to the values of the shielding parameters. Finally, the level of shielding for individuals engaged in "normal activity" falls in between the levels for evacuation and for sheltering, with reductions in doses from direct plume exposure and plume inhalation relative to evacuees of 25% and 59%, respectively.

TABLE 3: Terrorist attack at IP 2, MACCS2 estimates of early fatalities (EFs), latent cancer fatalities (LCFs) and the EF distance resulting from emergency phase exposures, 100% evacuation of EPZ

	Mean	95th percentile	99.5th percentile	Peak
Consequence:				
EFs, within EPZ	527	2,440	11,500	26,200
EFs, 0-50 mi.	696	3,460	16,600	43,700
EF distance (mi.)	5.3	18	24	60
LCFs, within EPZ	9,200	31,600	59,000	89,500
LCFs, 0-50 mi.	28,100	99,400	208,000	518,000

TABLE 4: Terrorist attack at IP 2, MACCS2 estimates of early fatalities (EFs), latent cancer fatalities (LCFs) and the EF distance resulting from emergency phase exposures, 24-hour sheltering in EPZ

	Mean	95th percentile	99.5th percentile	Peak
Consequence:				
EFs, within EPZ	626	2,550	6,370	13,000
EFs, 0-50 mi.	795	3,250	10,200	38,700
EF distance (mi.)	6.2	18	24	60
LCFs, within EPZ	3,770	9,920	12,100	19,400
LCFs, 0-50 mi.	22,700	81,000	192,000	512,000

TABLE 5: Terrorist attack at IP 2, MACCS2 estimates of early fatalities (EFs), latent cancer fatalities (LCFs) and the EF distance resulting from emergency phase exposures, normal activity in EPZ

	Mean	95^{th} percentile	99.5^{th} percentile	Peak
Consequence:				
EFs, within EPZ	4,050	12,600	22,300	38,500
EFs, 0-50 mi.	4,220	13,500	27,300	71,300
EF distance (mi.)	9	18	24	60
LCFs, within EPZ	4,480	10,400	12,500	20,300
LCFs, 0-50 mi.	23,400	82,600	193,000	516,000

A comparison of Tables 3 and 4 indicates that sheltering instead of evacuation results in slightly higher mean early fatalities, but substantially lower 99.5^{th} percentile and peak values. A possible interpretation of this counterintuitive result is that the higher percentile early fatality results for the evacuation case correspond to rare situations in which people evacuate in such a manner as to maximize their radiation exposure (for instance, if they are unfortunate enough to be traveling directly underneath the radioactive plume at the same speed and in the same direction). These situations cannot occur for the sheltering case. Overall, sheltering does appear to substantially reduce the projected number of latent cancer fatalities within the EPZ relative to evacuation, for the default MACCS2 shielding parameters.

A comparison of Table 5 to Tables 3 and 4 indicates that either evacuation or sheltering would substantially reduce the number of early fatalities within the EPZ relative to a case where no protective actions are taken. Also, by comparing Tables 3 and 5, one sees that the number of latent cancer fatalities in the EPZ is considerably lower for the normal activity case than for the evacuation case. There are two reasons for this. First, many evacuees will receive doses that are not high enough to cause early fatalities, yet will contribute to their lifetime cancer risk. In the normal activity case, some of these individuals will receive higher doses and succumb to acute radiation syndrome instead. Second, the MACCS2 default shielding factors give considerable protection to individuals engaged in normal activity compared to evacuees, and may not be realistic.[57]

The peak numbers of latent cancer fatalities for all three cases in the 50-mile zone are disturbingly high, and are more than double the number in the 99.5^{th} percentile. But an examination of the particular weather sequence corresponding to this result indicates that

[57] The protection due to shielding has a bigger impact on the number of latent cancer fatalities, which is a linear function of population dose, than on the number of early fatalities, which is a non-linear function of dose. Shielding would only prevent early fatalities for those individuals whose acute radiation doses would be lowered by sheltering from above to below the early fatality threshold.

the rarity of the event is an artifact of the meteorological data file that we have used, and not a consequence of very extreme or unusual weather conditions for the New York City region. We are not disclosing the details of this weather sequence.

The reader may also notice that the values for the "early fatality distance" for the 95th percentile and above are the same in Tables 3-5, but the mean values are not. This is because the distances for the 95th percentile and above are all greater than 10 miles, so that they are not affected by differences in protective actions that apply only within the 10-mile EPZ.

(b) Doses received by individuals outside of the 10-mile EPZ

It is clear from the previous section that direct exposure to the radioactive plume resulting from a terrorist attack at Indian Point could have severe consequences well beyond the 10-mile EPZ, yet there is no regulatory requirement that local authorities educate residents outside of the EPZ about these risks, or undertake emergency planning to protect these individuals from plume exposures. Therefore, individuals who are now at risk do not have the information that they may need to protect themselves. This is a shortsighted policy, and in fact is inconsistent with government guidelines for protective actions in the event of a radiological emergency.

In this section, we calculate the plume centerline thyroid doses to adults and five-year-old children, and the plume centerline whole-body doses to adults, both at the EPZ boundary and in midtown New York City. (For a given distance downwind of a release, the maximum dose is found at the plume centerline.) We then compare these values to the appropriate protective action recommendations. Thyroid doses are compared to the dose thresholds in the most recent FDA recommendations for potassium iodide administration and whole-body doses are compared to the EPA protective action guides (PAGs) for emergency-phase evacuation. In both cases, the plume centerline doses received to individuals in New York City are well in excess of the projected dose thresholds that would trigger protective actions.

(i) Thyroid doses to children, their consequences, and the need for KI distribution

The statistically significant increase in the incidence of thyroid cancer observed among children exposed to fallout from the Chernobyl disaster leaves little doubt of the causal relationship between the occurrence of these cancers and the massive release of radioactive iodine to the environment resulting from the accident.[58] The effectiveness of widespread distribution of stable iodine in the form of potassium iodide (KI) to block uptake of radioactive iodine in the thyroid was also confirmed in western areas of Poland, where the timely administration of KI was estimated to have reduced peak doses from radioactive iodine by 30%.[59]

[58] D. Williams, "Cancer After Nuclear Fallout: Lessons from The Chernobyl Accident," *Nature Reviews Cancer* **2** (2002), p. 543-549.
[59] Board on Radiation Effects Research, National Research Council, *Distribution and Administration of Potassium Iodide in the Event of a Nuclear Incident*, National Academies Press, 2003, p. 58.

In the United States, after resisting public demands for many years, the Nuclear Regulatory Commission finally agreed in January 2001 to amend its emergency planning regulations to explicitly consider the use of KI, and to fund the purchase of KI for distribution within the 10-mile plume exposure EPZs of nuclear plants in states that requested it. This effort accelerated after the September 11 attacks, as more states requested the drug, but even today only fewer than two-thirds of the 34 states and tribal governments that qualify for the KI purchase program have actually stockpiled it. New York State is one of the participants.

Despite a few attempts in Congress after September 11 to require the distribution of KI in areas outside of the plume exposure EPZs, the 10-mile limit remains in effect today, and NRC continues to defend it. In a recent Commission meeting on emergency planning, NRC employee Trish Milligan said that[60]

> "...the [NRC] staff has concluded that recommending consideration of potassium iodide distribution out to 10 miles was adequate for protection of the public health and safety."

Earlier in this briefing, Ms. Milligan provided evidence of the NRC staff's thinking that led to this conclusion:[61]

> "When the population is evacuated out of the [10-mile] area and potentially contaminated foodstuffs are interdicted, the risk from further radioactive iodine exposure to the thyroid gland is essentially eliminated."

These statements again show that NRC continues to use design-basis accidents, in which the containment remains intact, as the model for its protective action recommendations. Although NRC claims that its emergency planning requirements take into account all potential releases, including those resulting from terrorist acts, it clearly is not taking into account catastrophic events such as the scenario being analyzed in this report.

These statements also suggest that NRC is committing the fallacy of using the pattern of radioactive iodine exposure that occurred after the Chernobyl accident as the model for the pattern that could occur here. In the Chernobyl event, the majority of the thyroid dose to children occurred through ingestion of contaminated milk and other foodstuffs that were not interdicted due to the failure of the Soviet authorities to act in a timely manner. However, the food pathway dominated in that case primarily because of the extremely high elevation of the Chernobyl plume, which reduced the concentration of radioactive iodine in the plume and therefore the doses received through direct inhalation.
But as pointed out earlier, the plume from a severe accident at a water-moderated PWR like Indian Point would probably not rise as high as the Chernobyl plume, and the associated collective thyroid dose would have a greater contribution from direct plume inhalation and a lower contribution from milk consumption. In this case, the importance

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[60] US NRC, "Briefing on Emergency Preparedness Program Status" (2003), transcript, p. 21.
[61] Ibid, p.19.

of KI prophylaxis would increase relative to that of milk interdiction for controlling overall population exposure to radioactive iodine.

Our calculations clearly indicate that a severe threat to children from exposure to radioactive iodine is present far beyond the 10-mile EPZ where KI is now being made available. In Table 6, we present some results of the distribution for plume centerline thyroid dose to both adults and to five-year-old children at the EPZ boundary and in midtown Manhattan (32.5 miles downwind). In the last column, we provide the projected dose thresholds from the most recent guidelines issued by the FDA for KI prophylaxis.

The thyroid dose to five-year-olds due to I-131 internal exposure was calculated by using the age-dependent coefficients for dose per unit intake provided in ICRP 72, which are approximately a factor of five greater than those for adults. The calculation must also take into account the difference in the rate of intake of air for children and for adults. Children have lower lung capacities than adults, but they have higher metabolic rates and therefore breath more rapidly. The higher breathing rate of children tends to partially offset their lower lung capacity. Data collected by the California Environmental Protection Agency indicates that on average, children consume air at a rate about 75% of that of adults.[62] We have used this figure in our calculation.

TABLE 6: Terrorist attack at IP 2, MACCS2 estimates of centerline thyroid doses to 5-year-olds resulting from emergency phase exposures (all doses in rem)

Location	Age	Mean	95^{th} percentile	99.5^{th} percentile	Peak	FDA KI threshold
Outside EPZ	Adult	1,120	3,400	5,850	9,560	10 (ages 18-40) 500 (over 40)
(11.6 mi)	5 years	3,620	10,900	18,000	32,100	5
Midtown Manhattan	Adult	164	429	761	1,270	10 (ages 18-40) 500 (over 40)
(32.5 mi)	5 years	530	1,310	2,500	4,240	5

The results in Table 6 show that the thyroid doses to 5-year-olds are approximately three times greater than those for adults. This tracks well with information in the World Health Organization's 1999 guidelines for iodine prophylaxis, which states that thyroid doses from inhalation in children around three years old will be increased up to threefold relative to adults.[63]

[62] Air Resources Board, California Environmental Protection Agency, "How Much Air Do We Breathe?", Research Note #94-11, August 1994. On the Web at www.arb.ca.gov/research/resnotes/notes/94-11.htm.
[63] World Health Organization, *Guidelines for Iodine Prophylaxis Following Nuclear Accidents*, WHO, Geneva, 1999, Sec. 3.3.

These results make clear that both 95th percentile and mean projected thyroid doses can greatly exceed the FDA-recommended threshold for KI prophylaxis administration at locations well outside the 10-mile EPZ, for 5-year-old children and for adults of all ages. In Manhattan, KI would be recommended for children and adults under 40, based on the 95th percentile projection.

The health consequences of doses of this magnitude to the thyroid would be considerable. As the 99.5th percentile is approached, the 5-year-old doses are high enough to cause death of thyroid tissue. In fact, they are on the order of the doses that are applied therapeutically to treat hyperthyroidism and other diseases by destroying the thyroid gland. Children with this condition would require thyroid hormone replacement therapy for their entire lives. At lower doses, in which cells are not killed but DNA is damaged, the risk of thyroid cancer to children would be appreciable. According to estimates obtained from Chernobyl studies, a 95th percentile thyroid dose of 1,310 rem to a 5-year-old child in Manhattan would result in an excess risk of about 0.3% per year of contracting thyroid cancer.[64] Given that the average worldwide rate of incidence of childhood thyroid cancer is about 0.0001% per year, this would represent an impressive increase.

These results directly contradict the reassuring statements by NRC quoted earlier. But it is no secret to NRC that such severe thyroid exposures can occur as the result of a catastrophic release. Results very similar to these were issued by NRC staff in 1998 in the first version of a draft report on the use of KI, NUREG-1633.[65] This draft included a Section VII entitled "Sample Calculations," in which the NRC staff estimated the centerline thyroid doses at the 10-mile EPZ boundary from severe accidents using the RASCAL computer code. Table 5 of the draft report shows that the NRC's calculated dose to the adult thyroid at the 10-mile limit ranged from 1500 to 19,000 rem for severe accidents with iodine release fractions ranging from 6 to 35%, for a single weather sequence.[66] In the introductory section, the report states that "doses in the range of 25,000 rad are used to ablate thyroids as part of a therapeutic procedure. Such thyroid doses are possible during severe accidents."[67] NRC's results are even more severe than ours, which were obtained using the NRC revised source term, with a higher iodine release fraction of 67%.

Given NRC's reluctance to provide information of this type to the public, it is no surprise that the Commission withdrew the draft NUREG-1633 and purged it from its web site, ordering the issuance of a "substantially revised document" taking into account "the many useful public comments" that it received.[68] Lo and behold, the second draft of

[64] The average excess absolute risk per unit thyroid dose for children exposed to Chernobyl fallout has been estimated 2.1 per million children per rad. D. Williams, op cit., p. 544.
[65] F.J. Congel et al., *Assessment of the Use of Potassium Iodide (KI) As A Public Protective Action During Severe Reactor Accidents*, Draft Report for Comment, NUREG-1633, US Nuclear Regulatory Commission, July 1998.
[66] Ibid, p. 26.
[67] Ibid, p. 6.
[68] US NRC, "Staff Requirements --- Federal Register Notice on Potassium Iodide," SRM-COMSECY-98-016, September 30, 1998.

NUREG-1633, which was rewritten by Trish Milligan and reissued four years later, mysteriously failed to include Section VII, "Sample Calculations," as well as all information related to those calculations (such as the clear statement cited earlier that thyroid doses in the range of 25,000 rad are possible during severe accidents).[69] This took place even though the Commission's public direction to the NRC staff on changes to be incorporated into the revision made no explicit reference to this section.[70] However, it is clear that the expurgated information would be inconsistent with NRC's previous rulemaking restricting consideration of KI distribution only to the 10-mile zone. Even after this exercise in censorship, the Commission still voted in 2002 to block release of the revised draft NUREG-1633 as a final document.

Some insight into the level of understanding of the health impacts of a catastrophic release of radioactive iodine of the current Commission can be found in the statement of Commissioner McGaffigan in voting to delay release of the revised NUREG-1633 for public comment. In his comments, McGaffigan wrote[71]

> "Both WHO [the World Health Organization] and FDA set the intervention level on KI prophylaxis for those over 40 at 5 gray (500 rem) to the thyroid ... Since we do not expect, *even in the worst circumstances*, any member of the public to receive 500 rem to the thyroid, it would be useful for FDA to clarify whether we should plan for KI prophylaxis for those over 40." [Emphasis added.]

This statement is not consistent with what is known about the potential consequences of a severe nuclear accident. Few experts would claim that such high doses cannot occur "even in the worst circumstances," and the NRC's own emergency planning guidance is not intended to prevent such doses in *all* accidents, but only in *most* accidents. Given that the Commissioner presumably read the first draft of NUREG-1633, he would have seen the results of the staff's thyroid dose calculations and other supporting material. There is no discussion in the public record that provides a rationale for Commissioner McGaffigan's rejection of the informed judgment and quantitative analysis of his technical staff.

In 2003, at the request of Congress a National Research Council committee released a report addressing the issue of distribution and administration of KI in the event of a nuclear incident.[72] Most notably, the committee concluded that[73]

> "1. KI should be available to everyone at risk of significant health consequences from accumulation of radioiodine in the thyroid in the event of a radiological incident...

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[69] US NRC, "Status of Potassium Iodide Activities, SECY-01-0069, Attachment 1 (NUREG-1633, draft for comment; prepared by P.A. Milligan, April 11, 2001).
[70] US NRC, SRM-COMSECY-98-016.
[71] US NRC, Commission Voting Record on SECY-01-0069, "Status of Potassium Iodide Activities," June 29, 2001.
[72] National Research Council (2003), op cit.
[73] Ibid, p. 5.

2. KI distribution programs should consider … local stockpiling outside the emergency planning zone …"

While the committee did not itself take on the politically sensitive question of how to determine the universe of individuals who would be "at risk of significant health consequences," it did recommend that "the decision regarding the geographical area to be covered in a KI distribution program should be based on risk estimates derived from calculations of site-specific averted thyroid doses for the most vulnerable populations."[74] This is the type of information that we provide in Table 6 (and the type that NRC struck from draft NUREG-1633). We hope that the information in our report provides a starting point for state and local municipalities to determine the true extent of areas that could be significantly affected by terrorist attacks at nuclear plants in their jurisdiction and to make provisions for availability of KI in those regions. Our calculations show that New York City should be considered part of such an area.

However, even timely administration of KI to all those at risk can only reduce, but cannot fully mitigate, the consequences of a release of radioactive iodine resulting from a terrorist attack at Indian Point. The projected dose to individuals who undergo timely KI prophylaxis can be reduced by about a factor of 10. A review of the results of Table 6 shows that doses and cancer risks to many children in the affected areas will still be high even after a ten-fold reduction in received dose. And KI can only protect people from exposure to radioactive iodine, and not from exposure to the dozens of other radioactive elements that would be released to the environment in the event of a successful attack.

(ii) Whole-body doses and the need for evacuation or sheltering

In addition to KI distribution, the other major protective action that will be relied on to reduce exposures following a terrorist attack at Indian Point is evacuation of the population at risk. In Table 7, we present the results of our calculation for the projected centerline whole-body "total effective dose equivalents" (TEDEs) just outside the EPZ boundary and in downtown Manhattan, and compare those with the EPA recommended dose threshold for evacuation during the emergency phase following a radiological incident. As in the discussion of projected thyroid doses and KI prophylaxis, we find that projected centerline TEDEs would exceed the EPA Protective Action Guide (PAG) for evacuation of 1-5 rem at distances well outside of the 10-mile plume exposure EPZ within which NRC requires evacuation planning.

[74] Ibid, p. 162.

TABLE 7: Terrorist attack at IP 2, MACCS2 estimates of adult centerline whole-body total effective dose equivalents (TEDEs) resulting from emergency phase exposures (all doses in rem)

	Mean	95th percentile	99.5th percentile	Peak	EPA PAG
Location					
EPZ boundary (11.6 mi)	198	549	926	1,490	1-5
Midtown Manhattan (32.5 mi)	30	77	131	307	1-5

From the results in Table 7, it is clear that according to the EPA early phase PAG for evacuation of 1-5 rem, evacuation would be recommended for individuals in the path of the plume centerline not only outside of the EPZ boundary, but in New York City and beyond. An individual in Manhattan receiving the 95th percentile TEDE of 77 rem during the emergency phase period would have an excess absolute lifetime cancer fatality risk of approximately 8%, which corresponds to a 40% increase in the lifetime individual risk of developing a fatal cancer (which is about one in five in the United States).

We now examine the potential reduction in health consequences that could result from evacuation of a larger region than the current 10-mile EPZ by considering a case in which the boundary of the plume exposure EPZ is expanded from 10.7 to 25 miles. We calculate the impact of different protective actions in this region on the numbers of early fatalities and latent cancer fatalities among the population within the expanded EPZ but outside of the original 10-mile EPZ. The residents of the expanded EPZ are assumed either (1) to evacuate with the same mobilization time and at the same average speed as the residents of the original EPZ, or (2) to shelter in place for 24 hours and then evacuate. The results are provided in Table 8.

TABLE 8: Terrorist attack at IP 2, MACCS2 95th percentile estimates of early fatalities (EFs) and latent cancer fatalities (LCFs) resulting from emergency phase exposures; 25-mile EPZ

	Normal activity	Evacuation	Sheltering for 24 hrs
Consequence:			
EFs, 10.7-25 mi	664	0	0
LCFs, 10.7-25 mi	19,800	45,700	9,020

These results indicate that evacuation and sheltering are equally effective in eliminating the risk of early fatalities among residents of the 10.7-25 mile region for the 95th percentile case. On the other hand, one sees that evacuation also tends to increase the number of latent cancer fatalities relative to normal activity, while sheltering reduces the number. Thus for this scenario, it appears that sheltering of individuals in the 10.7-25 mile region would be preferable to evacuation of this region for the MACCS2 evacuation and sheltering models we use here. This is consistent with the results we obtained earlier when considering the comparative impacts of evacuation and sheltering of residents of the 10-mile EPZ, again indicating that evacuation tends to increase population doses by placing more people in direct contact with the radioactive plume. However, other models and other shielding parameter choices may lead to different conclusions. We would urge emergency planning officials to evaluate an exhaustive set of scenarios, and to conduct a realistic and site-specific assessment of the degrees of shielding that structures in the region may provide, to determine what types of actions would provide the greatest protection for residents of regions outside of the 10-mile EPZ.

(c) Long-term economic and health consequences

In this section we provide MACCS2 order-of-magnitude estimates of the economic costs of the terrorist attack scenario, the numbers of latent cancer fatalities resulting from long-term radiation exposures (primarily as a result of land contamination), and the number of people who will require permanent relocation. NRC has used MACCS2 to estimate the economic damages of reactor accidents for various regulatory applications.[75]

There is no unique definition of the economic damages resulting from a radiological contamination event. In the MACCS2 model, which is a descendant of the CRAC2 model, the total economic costs include the cost of decontamination to a user-specified cleanup standard, the cost of condemnation of property that cannot be cost-effectively decontaminated to the specified standard, and a simple lump-sum compensation payment to all members of the public who are forced to relocate either temporarily or permanently as a result of the attack. Although simplistic, this model does provide a reasonable estimate of the order of magnitude of the direct economic impact of a successful terrorist attack at Indian Point.

(i) EPA Protective Action Guide cleanup standard

We first employ the long-term habitability cleanup standards provided by the EPA protective action guide (PAG) for the "intermediate phase," which is the period that begins after the emergency phase ends, when releases have been brought under control and accurate radiation surveys have been taken of contaminated areas. The EPA intermediate phase PAG recommends temporary relocation of individuals and decontamination if the projected whole-body total effective dose equivalent (TEDE) (not taking into account any shielding from structures) over the first year after a radiological

[75] US NRC, Office of Nuclear Regulatory Research, *Regulatory Analysis Technical Evaluation Handbook*, NUREG/BR-0184, January 1997, p. 5.37.

release would exceed 2 rem. The EPA chose this value with the expectation that if met, then the projected (shielded) TEDE in the second (and any subsequent year) would be below 0.5 rem, and the cumulative TEDE over a fifty-year period would not exceed 5 rem.

The MACCS2 economic consequence model evaluates the cost of restoring contaminated areas to habitability (which we define as reducing the unshielded TEDE during the first year of reoccupancy to below 2 rem), and compares that cost to the cost of condemning the property. All cost parameters, including the costs of decontamination, condemnation and compensation, can be specified by the user. We employ an economic model partly based on parameters developed for a recent study on the consequences of spent fuel pool accidents.[76] The model utilizes the results of a 1996 Sandia National Laboratories report that estimates radiological decontamination costs for mixed-use urban areas.[77] We refer interested readers to these two references for information on the limitations and assumptions of the model.

The SECPOP2000 code, executed for the Indian Point site, provides the required site-specific inputs for this calculation, including the average values of farm and non-farm wealth for each region of the MACCS2 grid, based on 1997 economic data. These values are used to assess the cost-effectiveness of decontaminating a specific element versus simply condemning it.

Table 9 presents the long-term health and economic consequences calculated by MACCS2 for a region 100 miles downwind of the release, considering only costs related to residential and small business relocation, decontamination and compensation. Since the calculation was performed using values from a 1996 study and from 1997 economic data, we have converted the results to 2003 dollars using an inflation adjustment factor of 1.10. Because of significant uncertainties in the assignments of parameters for this calculation, the results in Table 9 should only be regarded as order-of-magnitude estimates. The reader should note that the latent cancer fatality figures in Table 9 result from doses incurred after the one-week emergency phase is over, and therefore are additional to the numbers of latent cancer fatalities resulting from emergency-phase exposures reported previously in Tables 3 to 5.

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[76] J. Beyea, E. Lyman and F. von Hippel, "Damages from a Major Release of ^{137}Cs into the Atmosphere of the United States," *Science and Global Security* 12 (2004) 1-12.

[77] D. Chanin and W. Murfin, *Site Restoration: Estimates of Attributable Costs From Plutonium Dispersal Accidents*, SND96-0057, Sandia National Laboratories, 1996.

TABLE 9: Terrorist attack at IP 2, MACCS2 estimates of long-term economic and health consequences, EPA intermediate phase PAG (< 2 rem in first year; approx. 5 rem in 50 yrs)

Consequence	Mean	95th percentile	99.5th percentile	Peak
Total cost, 0-100 mi (2003 $)	$371 billion	$1.17 trillion	$1.39 trillion	$2.12 trillion
People permanently relocated	684,000	3.19 million	7.91 million	11.1 million
LCFs, 0-100 mi	12,000	41,200	57,900	84,900
Plume Centerline 50-year TEDE (rem)	4.57	7.04	7.18	7.42

One can see from Table 9 that imposition of the EPA intermediate phase PAG does result in restricting the mean 50-year cumulative TEDE to below 5 rem, but that this limit is exceeded for the higher percentiles of the distribution. Thus for a terrorist attack at the 95th percentile, the subsidiary goal of the EPA intermediate phase PAG is not met.

(ii) Relaxed cleanup standard

In the recent NRC meeting on emergency planning described earlier, NRC staff and Commissioners questioned claims by activists that a severe nuclear accident would render large areas "permanently uninhabitable," arguing that the radiation protection standard underlying that determination is too stringent compared to levels of natural background radiation to which people are already exposed.

For instance, Trish Milligan said that[78]

> "There's been a concern that a radioactive release as a result of a nuclear power plant accident will render thousands of square miles uninhabitable around a plant. It is true that radioactive materials can travel long distances. But it is simply not true that the mere presence of radioactive materials are [sic] harmful... the standard applied to this particular claim has been a whole body dose of 10 rem over 30 years, or approximately 330 millirem per year. This dose is almost the average background radiation dose in the United States which is about 360 millirem per year. Some parts of the country have a background radiation dose two or more times higher than the national average. So in effect this additional 330 millirem dose is an additional year background dose or the difference in dose

[78] US NRC, Briefing on Emergency Preparedness (2003), op cit., transcript, p. 22.

> between someone living in a sandy coastal area or someone living in the Rocky Mountains."

Ms. Milligan does not note that her opinion of an acceptable level of radiation is not consistent with national standards, such as the EPA PAGs. The EPA long-term goal of limiting chronic exposures after a radiological release to 5 rem in 50 years corresponds to an average annual exposure of 100 millirem above background, while she implies that even a standard of 330 millirem per year, which would double the background dose on average, is unnecessarily stringent.

However, we can evaluate the impact of weakening the EPA PAGs for long-term exposure on costs and risks. In Table 10, we assess the impact of adopting a long-term protective action guide of 25 rem in 50 years, or an average annual dose of 500 millirem per year. By comparing the 95th percentile columns in Table 10 and Table 9, one can see that relaxing the standard would modestly reduce the post-release cleanup costs by about 25% and drastically reduce the number of relocated individuals by 90%. However, weakening the standard would nearly triple the number of long-term cancer deaths among residents of the contaminated area. Cost-benefit analyses of proposals to weaken long-term exposure standards should take this consequence into account.

TABLE 10: Long-term economic and health consequences of a terrorist attack at IP 2, relaxed cleanup standard (25 rem in 50 years)

	Mean	95th percentile	99.5th percentile	Peak
Consequence:				
Total cost, 0-100 mi (2003 $)	$249 billion	$886 billion	$1.14 trillion	$1.50 trillion
People permanently relocated	118,000	334,000	1.86 million	7.98 million
LCFs, 0-100 mi	36,300	115,000	169,000	279,000

(d) An even worse case

The previous results were based on the analysis of a terrorist attack that resulted in a catastrophic radiological release from only one of the two operating reactors at the Indian Point site. However, it is plausible that both reactors could be attacked, or that an attack on one could result in the development of an unrecoverable condition at the other. Here we present the results of a scenario in which Indian Point 3 undergoes a similar accident sequence to Indian Point 2 after a time delay of just over two hours. This could occur, for example, if Indian Point 3 experienced a failure of its backup power supplies at the time that Indian Point 2 was attacked. Given the loss of off-site power at the same time, Indian Point 3 could experience a small-break LOCA and eventually a core melt, commencing about two hours after accident initiation. We assume that the attackers

weaken the IP3 containment so that it ruptures at the time of vessel failure. In Table 11, we present the results of this scenario for the case of full evacuation of the EPZ.

As bad as this scenario is, it still does not represent the worst case. If any or all of the three spent fuel pools at the Indian Point site were also damaged during the attack, the impacts would be far greater, especially with regard to long-term health and economic consequences.

TABLE 11: Terrorist attack at IP 2 and 3, MACCS2 estimates of early fatalities (EFs) and latent cancer fatalities (LCFs) resulting from emergency phase exposures, 100% evacuation of EPZ

	Mean	95th percentile	99.5th percentile	Peak
Consequence:				
EFs, within EPZ	925	4,660	18,400	34,100
EFs, 0-50 mi.	1,620	8,580	30,900	78,400
EF, distance (mi.)	9.1	21	29	60
LCFs, within EPZ	14,800	42,900	75,100	122,000
LCFs, 0-50 mi.	53,400	180,000	342,000	701,000

CONCLUSIONS

In conclusion, we make the following observations.

1) The current emergency planning basis for Indian Point provides insufficient protection for the public within the 10-mile emergency planning zone in the event of a successful terrorist attack. Even in the case of a complete evacuation, up to 44,000 early fatalities are possible.

2) The radiological exposure of the population and corresponding long-term health consequences of a successful terrorist attack at Indian Point could be extremely severe, even for individuals well outside of the 10-mile emergency planning zone. We calculate that over 500,000 latent cancer fatalities could occur under certain meteorological conditions. A well-developed emergency plan for these individuals, including comprehensive distribution of potassium iodide throughout the entire area at risk, could significantly mitigate some of the health impacts if promptly and effectively carried out. However, even in the case of 100% evacuation within the 10-mile EPZ and 100% sheltering between 10 and 25 miles, the consequences could be catastrophic for residents of New York City and the entire metropolitan area.

3) The economic impact and disruption for New York City residents resulting from a terrorist attack on Indian Point could be immense, involving damages from hundreds of billions to trillions of dollars, and the permanent displacement of millions of individuals. This would dwarf the impacts of the September 11 attacks.

4) The potential harm from a successful terrorist attack at Indian Point is significant even when only the mean results are considered, and is astonishing when the results for 95th and 99.5th meteorological conditions are considered. Given the immense public policy implications, a public dialogue should immediately be initiated to identify the protective measures desired by the entire affected population to prevent such an attack or effectively mitigate its consequences should prevention fail. As this study makes abundantly clear, this population extends far beyond the 10-mile zone that is the focus of emergency planning efforts today.

We hope that this information will be useful for officials in the Department of Homeland Security as it carries out its statutory requirement to conduct a comprehensive assessment of the terrorist threat to the US critical infrastructure, as well as for health and emergency planning officials in New York City and other areas that are not now currently engaged in emergency preparedness activities related to a terrorist attack at Indian Point.

ACKNOWLEDGMENTS

The author would like to thank David Lochbaum, Kenneth Bergeron, Frank von Hippel, Jan Beyea and Lisbeth Gronlund for reading drafts of this report and providing many useful comments and suggestions. All mistakes are the responsibility of the author.

United States General Accounting Office

GAO

Report to the Ranking Minority Member, Subcommittee on Financial Management, the Budget, and International Security, Committee on Governmental Affairs, U.S. Senate

August 2003

NUCLEAR SECURITY

Federal and State Action Needed to Improve Security of Sealed Radioactive Sources

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GAO-03-804

August 2003

NUCLEAR SECURITY

Federal and State Action Needed to Improve Security of Sealed Radioactive Sources

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Highlights

Highlights of GAO-03-804, a report to Ranking Minority Member, Subcommittee on Financial Management, the Budget, and International Security, Committee on Governmental Affairs, U.S. Senate

Why GAO Did This Study

Sealed radioactive sources, radioactive material encapsulated in stainless steel or other metal, are used worldwide in medicine, industry, and research. These sealed sources could be a threat to national security because terrorists could use them to make "dirty bombs." GAO was asked to determine (1) the number of sealed sources in the United States, (2) the number of sealed sources lost, stolen, or abandoned, (3) the effectiveness of federal and state controls over sealed sources, and (4) the Nuclear Regulatory Commission (NRC) and state efforts since September 11, 2001, to strengthen security of sealed sources.

What GAO Recommends

GAO recommends that NRC (1) collaborate with states to determine availability of highest risk sealed sources, (2) determine if owners of certain devices should apply for licenses, (3) modify NRC's licensing process so sealed sources cannot be purchased until NRC verifies their intended use, (4) ensure that NRC's evaluation of federal and state programs assess security of sealed sources, and (5) determine how states can participate in implementing additional security measures. NRC stated that some of our recommendations would require statutory changes. We clarified our report language to address this concern. Agreement states and an organization of radiation experts agreed with our recommendations.

www.gao.gov/cgi-bin/getrpt?GAO-03-804.

To view the full report, including the scope and methodology, click on the link above. For more information, contact Gene Aloise at (202) 512-6870 or aloisee@gao.gov.

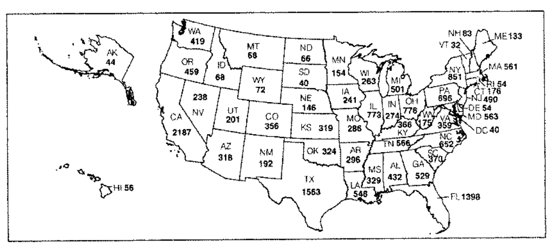
What GAO Found

The number of sealed sources in the United States is unknown because NRC and states track numbers of licensees instead of individual sealed sources. Users of certain devices containing sealed sources are not required to apply to NRC for a license. Accounting for these devices has been difficult. In addition, since 1998, more than 1,300 incidents have taken place in the United States where sealed sources have been lost, stolen, or abandoned. The majority of these lost devices were recovered.

Security for sealed sources varied among the facilities GAO visited in 10 states. Also, a potential security weakness exists in NRC's licensing process to obtain sealed sources. Approved applicants may buy sealed sources as soon as a new license is issued by mail. Because the process assumes that the applicant is acting in good faith and it can take NRC as long as 12 months before conducting an inspection, it is possible that sealed sources can be obtained for malicious intent. In addition, NRC currently evaluates the effectiveness of state regulatory programs, but these evaluations do not assess the security of sealed sources.

Since the terrorist attacks of September 11, 2001, NRC and states have notified licensees of the need for heightened awareness to security, but have not required any specific actions to improve security. NRC has been developing additional security measures since the attacks, and issued the first security order to large facilities that irradiate such items as medical supplies and food on June 5, 2003. Additional orders to licensees that possess high risk sealed sources are expected to follow. NRC and states disagree over the appropriate role of states in efforts to improve security. NRC intends to develop and implement all additional security measures on licensees with sealed sources, including those licensed by states. However, over 80 percent of states responding to our survey feel they should be given responsibility to inspect and enforce security measures.

Number of Medical, Industrial, and Research Users of Sealed Sources (About 20,000 Total Nationwide) as of December 31, 2002



Sources: NRC license tracking system and GAO survey of agreement states.

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Abbreviations

CFR	Code of Federal Regulations
CRCPD	Conference of Radiation Control Program Directors
DOE	Department of Energy
DOT	Department of Transportation
GAO	General Accounting Office
NRC	Nuclear Regulatory Commission
OAS	Organization of Agreement States

GAO
Accountability * Integrity * Reliability

United States General Accounting Office
Washington, D.C. 20548

August 6, 2003

The Honorable Daniel K. Akaka
Ranking Minority Member
Subcommittee on Financial Management,
the Budget, and International Security
Committee on Governmental Affairs
United States Senate

Dear Senator Akaka:

Since the September 11, 2001, terrorist attacks there has been concern that certain radioactive material, such as cobalt-60, strontium-90, iodine-131, cesium-137, iridium-192, and americium-241, could be used in the construction of a radiological dispersion device—commonly referred to as a "dirty bomb." Such radioactive materials are used in devices that treat cancer, sterilize food and medical instruments, and detect flaws in pipelines and other types of metal welds. Much of the radioactive material used in these devices is encapsulated, or sealed, in metal such as stainless steel, titanium, or platinum to prevent its dispersal.[1] A dirty bomb could be produced by using explosives in combination with radioactive material upon detonation. Most experts agree that the dispersed radioactive material would have few short-term health effects on exposed individuals and that the explosives, not the radioactive material, would likely cause the greatest amount of immediate injuries, fatalities, and property damage. However, a dirty bomb—depending on the type, form, amount, and concentration of radioactive material used—could cause radiation exposure in individuals in close proximity to the material for an extended time and potentially increase the long-term risks of cancer for those contaminated. In addition, the evacuation and cleanup of contaminated areas after such an explosion could lead to panic and serious economic costs on the affected population.

Under the Atomic Energy Act of 1954, the Nuclear Regulatory Commission (NRC) regulates domestic medical, industrial, and research uses of sealed sources through a combination of regulatory requirements, licensing,

[1]Some loose material, such as iodine-131, used in thyroid cancer treatments, and technetium-99m, commonly used in medical imaging procedures is not in sealed source form. However, for simplicity this report uses the term "sealed source" to refer to all radioactive materials used for medical, industrial, and research purposes.

inspection, and enforcement. Section 274 of the act authorizes NRC to give primary regulatory authority to states (called "agreement" states) under certain conditions.[2] To date, NRC has relinquished its licensing, inspection, and enforcement authority to 32 agreement states that administer the use of sealed sources within their jurisdictions;[3] while continuing to regulate the use of sealed sources in the remaining states. NRC periodically evaluates each agreement state's regulatory program for compatibility with NRC regulations and its effectiveness in protecting public health and safety. Two types of licenses are associated with the use of radioactive materials—general licenses and specific licenses. A generally licensed device usually contains a sealed source within a shielded device, such as gas chromatograph units, fixed gauges, luminous exit signs, or reference and check sources. Such devices are designed with inherent radiation safety features so that persons with little or no radiation training or experience can use it, and as such do not require NRC or agreement state approval to purchase and are widely commercially available. Specific licenses cover uses, such as cameras used for industrial radiography, medical devices used to treat cancer, and facilities that irradiate food or medical products for sterilization. These uses generally require larger amounts of radioactive material than can be obtained with a general license. Organizations or individuals wanting to obtain a specific license must submit an application and gain the approval of either NRC or an agreement state. In addition to NRC and agreement states, other federal agencies, such as the Department of Transportation, the Food and Drug Administration, and the Environmental Protection Agency, regulate the safe transportation, medical use, and cleanup of radioactive material. The Department of

[2]The purpose of section 274 of the Atomic Energy Act of 1954, as amended (42 U.S.C. § 2021) is to recognize the interest of the states in the peaceful uses of atomic energy and to establish programs for cooperation between the states and NRC to control the radiation hazards associated with the use of radioactive materials. While it details procedures for NRC to relinquish its regulatory authority to the states for medical, industrial, and research uses of radioactive materials, NRC retains sole regulatory authority over, among other things, nuclear power plants and the export and import of radioactive materials. In addition, NRC retains regulatory authority over federal facilities (such as Department of Defense bases or Veterans Administration hospitals)—see 10 C.F.R. § 30.6(b)(2).

[3]At the time of our report, Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Mississippi, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, Tennessee, Texas, Utah, and Washington were agreement states. NRC expects Wisconsin will become an agreement state in the summer of 2003.

Energy (DOE) regulates the use of radioactive material at its facilities and at the national laboratories.

This report—the third that we have prepared at your request to examine efforts to control sealed radioactive sources—examines efforts in the United States to regulate the use of sealed sources domestically and to prevent the use of this material by terrorists.[4] Specifically, you asked us to determine (1) the known number of sealed sources in the United States; (2) how many of these sealed sources have been lost, stolen, or abandoned; (3) the effectiveness of federal and state controls over sealed sources; and (4) NRC's and agreement states' efforts considered or implemented following September 11, 2001, to strengthen security of sealed sources. To address these objectives, we distributed a survey to radiation control agencies in the 32 agreement states, the 18 non-agreement states, the District of Columbia, and Puerto Rico to determine numbers and types of radioactive materials licenses in their jurisdictions and to solicit their views on the regulation of sealed sources. At the time of this report, all of the agreement states except Arizona, 11 non-agreement states, and Puerto Rico had responded to our survey. We did not receive responses from the following non-agreement states—Alaska, Connecticut, Minnesota, Missouri, Pennsylvania, South Dakota, Vermont, Wyoming, and the District of Columbia.[5] We also surveyed and interviewed officials in the four NRC regional offices; interviewed officials at NRC headquarters in Rockville, Maryland; and analyzed NRC license and incident databases. In addition, we observed NRC evaluations of the effectiveness of state regulatory programs in Rhode Island and Florida and a similar evaluation of NRC's Region III radioactive materials regulatory program in Lisle, Illinois. We visited 10 states to meet with officials of state radiation control agencies

[4]Our report, U.S. General Accounting Office, *Nuclear Nonproliferation: DOE Action Needed to Ensure Continued Recovery of Unwanted Sealed Radioactive Sources*, GAO-03-483 (Washington, D.C.: Apr. 15, 2003) examined DOE's efforts to recover and dispose of unwanted "greater-than-Class-C" sources—sources that typically contain greater concentrations of isotopes such as plutonium-238, plutonium-239, and americium-241, that cannot be disposed of at existing low-level radioactive waste facilities. Our report, U.S. General Accounting Office, *Nuclear Nonproliferation: U.S. and International Assistance Efforts to Control Sealed Radioactive Sources Need Strengthening*, GAO-03-638 (Washington, D.C.: May 16, 2003) examined international efforts conducted by the United States, the Russian Federation, the International Atomic Energy Agency, and others to control sealed sources.

[5]Although we did not receive surveys from these states, we obtained data on incidents involving sealed sources and numbers and types of licensees from NRC.

and selected licensees representing a variety of types and uses of sealed sources. Appendix I presents our scope and methodology in more detail.

Results in Brief

The precise number of sealed sources in use today in the United States is unknown. NRC estimates that there are approximately 2 million sealed sources in the United States. This estimate is based on the number of specific and general licensees from NRC's databases and agreement states combined with data from an NRC survey conducted in the early 1990s. NRC and agreement states do not track the actual numbers of sealed sources, but only track the number of specific licensees and have limited data on general licensees. NRC, in cooperation with DOE, has begun examining options for developing a national sealed source tracking system, but this effort is limited in scope; importantly, it has had only limited involvement of the agreement states. Our analysis of NRC's specific license database and responses to our survey of agreement states indicate that about 20,000 entities (companies, hospitals, organizations, and in some cases, individuals) have obtained specific licenses to possess and use radioactive material, including sealed sources. Agreement states regulate 80 percent of these entities, while NRC regulates the remaining 20 percent.

NRC has had difficulty accounting for generally licensed devices. Owners of these devices are not required to apply to NRC or agreement states for licenses. Mishandling and improper disposal of generally licensed devices has, in some cases, lead to expensive investigation and clean up. NRC began tracking generally licensed devices in April 2001, but has experienced problems locating device owners. To assist in this effort, NRC has contracted with a private investigation firm to help locate owners. In order to improve accountability over generally licensed devices, we are recommending that NRC determine the need to require owners of these devices to apply for specific licenses and whether the additional costs presented by applying for and approving specific licenses are commensurate with the risks these devices present.

Since 1998, there have been more than 1,300 reported incidents of lost, stolen, or abandoned devices containing sealed sources, an average of about 250 per year. The majority of these devices were subsequently recovered. Both NRC and DOE recognize the importance of determining how many sealed sources are present in the United States, and which sealed sources pose the greatest risk if they were to be used in a dirty bomb. NRC and DOE are working together to categorize sealed sources by their level of risk. However, NRC's and DOE's efforts are limited in scope

because they do not include an analysis of sealed sources in the agreement states, which regulate 80 percent of the nation's radioactive materials licensees. This is because there is no single source of data on agreement state licensees; instead each state has its own database of the licensees it regulates. These databases are not linked to one another and NRC does not have access to them. Therefore, we are recommending that NRC as part of its continuing efforts to categorize the sealed sources that pose the greatest risk, consult with the agreement states to determine the types, amount, and availability of the highest risk sealed sources.

Weaknesses exist in federal and state controls over the security of sealed sources. Our visits to radiation control programs and licensees in 10 states found that security for devices containing sealed sources varied among facilities we visited. For example, a medical device manufacturer that we visited had extensive security measures, including electronic access control to areas containing sealed sources, perimeter fencing, and background checks on employees. On the other hand, a medical use licensee that we visited kept its sealed sources in an unlocked, unguarded space with the door propped open. In addition, we found a potential security weakness in NRC's licensing process to obtain sealed sources. The process assumes an applicant is acting in good faith and allows applicants to acquire sealed sources as soon as a new license is issued by mail. It can then take NRC as long as 12 months to conduct its first inspection, leaving the possibility that materials will be obtained and used maliciously in the meantime. Certain agreement states have implemented measures to address this weakness, such as delivering licenses in person or conducting inspections before the delivery of sealed sources. In addition, NRC currently evaluates the effectiveness of state regulatory programs, but these evaluations do not assess the security of sealed sources. To address security weaknesses, we are recommending that NRC modify its licensing process to ensure that radioactive sources cannot be purchased before NRC verifies that the material will be used as intended. We are also recommending that NRC modify its evaluations of agreement state and NRC programs to include criteria and performance measures of program effectiveness in ensuring the security of sealed sources.

Since the terrorist attacks of September 11, 2001, NRC, along with the agreement states, has notified licensees of the need for heightened awareness to security and the need to take certain actions, but has not issued, until recently, legally binding orders to improve the security of sealed sources. NRC has been developing specific additional security measures since the attacks, and issued orders on June 5, 2003, to

strengthen security at large irradiator facilities. Although irradiator facilities contain large amounts of radioactive material, they are specially designed to include thick concrete and steel walls, security interlocks, and other protective equipment to protect against radiation exposure and secure the sealed sources. In light of such built-in security, agreement state officials and others have questioned NRC's decision to select irradiators as the first recipient of additional security measures. Of agreement states responding to our survey, 93 percent identified sealed sources used in industrial radiography as of greater concern. Reasons for this may include that these devices are widely available and portable.

NRC and some agreement states disagree on the appropriate role of the states in the regulation of sealed source security. The Atomic Energy Act of 1954 gives NRC the authority to issue rules, regulations, or orders to promote the common defense and security and to protect the health and minimize danger to life or property. Based on this authority, NRC intends to order licensees with sealed sources, including those licensed by agreement states, to implement additional security measures. NRC has already done so for large irradiator facilities. However, 82 percent of agreement states responding to our survey indicate that they want to have responsibility for inspection and enforcement of security measures for sealed sources. In addition, 74 percent of agreement states responding to our survey indicated that their state program could effectively respond to a radiological incident with its current resources. NRC officials argue that the agreement states lack the staff and funding to carry out the additional responsibility of securing sealed sources. However, according to NRC officials we contacted, NRC clearly faces similar staffing and funding problems. NRC has initiated a materials security working group, which includes the states, as a mechanism for discussing and identifying potential resolutions to these issues. We are recommending that NRC determine how agreement and non-agreement states can participate in the development and implementation of additional security measures over sealed sources.

We presented a draft of this report to NRC, the Conference of Radiation Control Program Directors (CRCPD), and the Organization of Agreement States (OAS) for comment. NRC stated that the draft report did not fully present either the current status of NRC's efforts to improve the security of high-risk radioactive sources or the large effort that NRC has devoted to this issue over the past 18 months. NRC believed that several of our recommendations would require statutory changes at both federal and state levels. We clarified our recommendations regarding the participation of the states in the development and implementation of additional security

measures. CRCPD and OAS officials generally agreed with our conclusions and recommendations.

Background

Radioactive material in sealed sources is used in equipment designed to diagnose and treat illnesses (particularly cancer), irradiate food and medical products for sterilization purposes, detect flaws and other failures in pipeline and other types of metal welds, and determine the moisture content of soil and other materials.[6] Until the 1950s, only naturally occurring radioactive materials, such as radium-226, were available to be used in sealed sources. Since then, sealed sources containing radioactive material produced artificially in nuclear reactors and particle accelerators have become widely available, including cobalt-60, strontium-90, technetium-99m, cesium-137, and iridium-192. Under the Atomic Energy Act of 1954, the states retain sole regulatory authority over most naturally occurring radioactive material as well as radioactive material produced in particle accelerators. Federal jurisdiction extends only to those materials used as a source of material for nuclear fuel or created as a result of irradiation in nuclear reactors.

Radioactive material can be found in various forms. For example, cobalt-60 is a metal, while the cesium-137 in some sealed sources is in a powder form closely resembling talc. Radioactive materials never stop emitting radiation, but their intensity decays over time at various rates. The term "half-life" is used to indicate the period during which the radioactivity decreases by half as a result of decay. Radioactive materials are measured by their level of activity. The greater the activity level—measured in units called curies[7]—the more radiation emitted, which increases the potential risk to the public if the radioactive materials are lost or stolen.

[6]See appendix II for a discussion of medical and industrial devices that use radioactive sources.

[7]The curie is the unit of measurement most commonly used in the United States. The corresponding international standard unit, the Bequerel (Bq) is the activity equal to one radioactive disintegration per second. One bequerel=2.7 x 10^{-11} curies.

Two types of licenses are associated with the use of radioactive materials—general licenses and specific licenses. A generally licensed device usually consists of a sealed source within a shielded device, such as gas chromatograph units, fixed gauges, luminous exit signs, or reference and check sources. These devices are designed with inherent radiation safety features so that persons with little or no radiation training or experience can use it. General licensees are automatically licensed without having to apply to NRC or an agreement state for a license and are subject to a variety of requirements under NRC's or agreement states' regulations.[8] Furthermore, manufacturers are required to report quarterly to NRC the names of customers who purchase generally licensed devices. Examples of requirements general licensees are subject to under NRC's regulations include:

- general licensees shall not abandon the devices;
- complying with instructions and precautions listed on device labels;
- performing tests to ensure radioactivity is not leaking from the device at least every 6 months, and, if leakage is detected, suspend operation of the device and have it repaired or disposed of by the manufacturer or another entity authorized to perform such work; and
- reporting to NRC or an agreement state the transfer of a device to another licensee or the disposal of the device.

A company seeking radioactive material for uses that do not qualify for a general license must apply to NRC or, if it conducts business in an agreement state, to the appropriate state for a specific license. Its application must demonstrate how the use of the materials will meet the safety requirements in NRC's or agreement states' regulations.[9] Applicants must provide information on the type, form, and intended quantity of material, the facilities in which the material will be used, the qualifications of users of the materials, and radiation protection programs the applicant has in place to protect their workers and the public from receiving excessive doses of radiation.

[8]NRC's regulations are at 10 C.F.R. § 31.5.

[9]NRC's regulations are at 10 C.F.R. Parts 19-21, 30-39, 40, 61, 70, and 71.

NRC and the Agreement States Lack Complete Information on Numbers of Sealed Sources

The number of sealed sources in use today in the United States is unknown primarily because no state or federal agency tracks individual sealed sources. Instead, NRC and the agreement states track numbers of specific licensees. NRC and DOE have begun to examine options for developing a national tracking system, but to date, this effort has had limited involvement by the agreement states. NRC had difficulty locating owners of certain generally licensed devices it began tracking in April 2001 and has hired a private investigation firm to help locate them. Twenty-five of the 31 agreement states that responded to our survey indicated that they track some or all general licensees or generally licensed devices, and 17 were able to provide data on the number of generally licensed devices in their jurisdictions, totaling approximately 17,000 devices.

NRC and Agreement States Track Licensees Rather Than Individual Sealed Sources

NRC estimates that there are approximately 2 million licensed sealed sources in the United States. However, there is no single source of information in the United States to verify authorized users, locations, quantities, and movements of sealed sources. Separate systems are in place at NRC and in each agreement state to track the identities of specific licensees and the maximum quantity of radioactive material that they are authorized to possess. These systems do not, however, record the number of sealed sources actually possessed by specific licensees nor do the systems track movements (such as purchase, transfer, or disposal) of sealed sources by specific licensees. Licensees are required to maintain records for the acquisition and disposition of each sealed source it receives and inspections by NRC and/or an agreement state includes confirming inventory records.

The Secretary of Energy and the Chairman of NRC established a working group in June 2002 to address, among other things, the options for establishing a national source tracking system and the potential for the use of technological methods for tagging and monitoring sealed sources in use, storage, and transit. This working group reported in May 2003 that a national source tracking system should provide a "cradle to grave" account of the origins of each high-risk source, and record how, by whom, and where a source has been transported, used, and eventually disposed of or exported. According to the report, such a system would help NRC and DOE to:

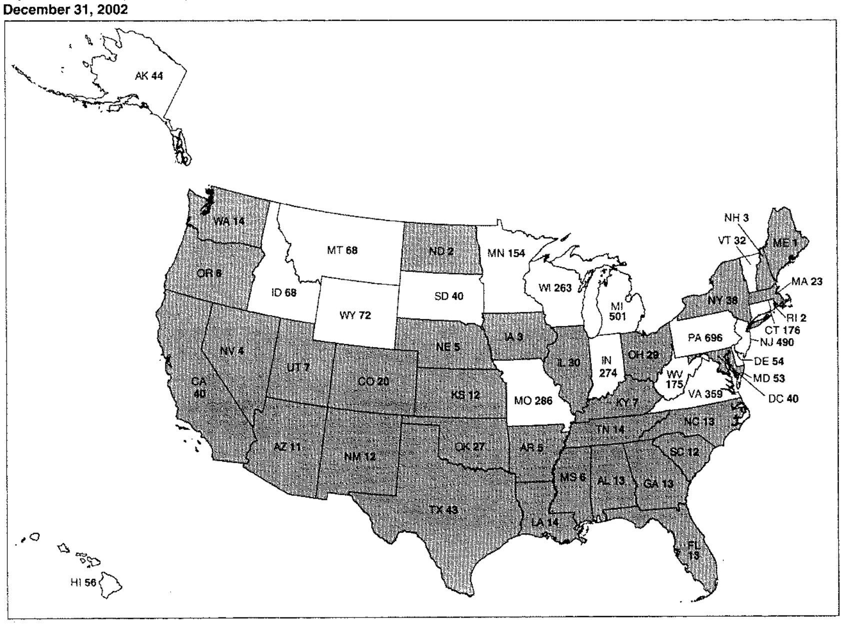
- monitor the location and use of sealed sources,

- detect and act on discrepancies,
- conduct inspections and investigations,
- communicate sealed source information to other government agencies,
- respond in the event of an emergency,
- verify legitimate ownership and use of sealed sources, and
- further analyze hazards attributable to the possession and use of sealed sources.

The working group did not determine how data on sealed source licensees in the agreement states would be integrated into a national level system.

While there are no complete data on the number of sealed sources in the United States, data are available on the number of specific licensees authorized to use sealed sources. Analysis of NRC's specific license database and responses to our survey of the agreement states indicates that there are about 20,000 specific licensees in the United States (see figs. 1 and 2). The majority (nearly 80 percent) are regulated by the 32 agreement states, the remaining 20 percent of specific licensees are regulated by NRC.

Figure 1: NRC Regulated Specific Licenses in NRC Regulated States and on Federal Facilities in Agreement States as of December 31, 2002



NRC states (18)

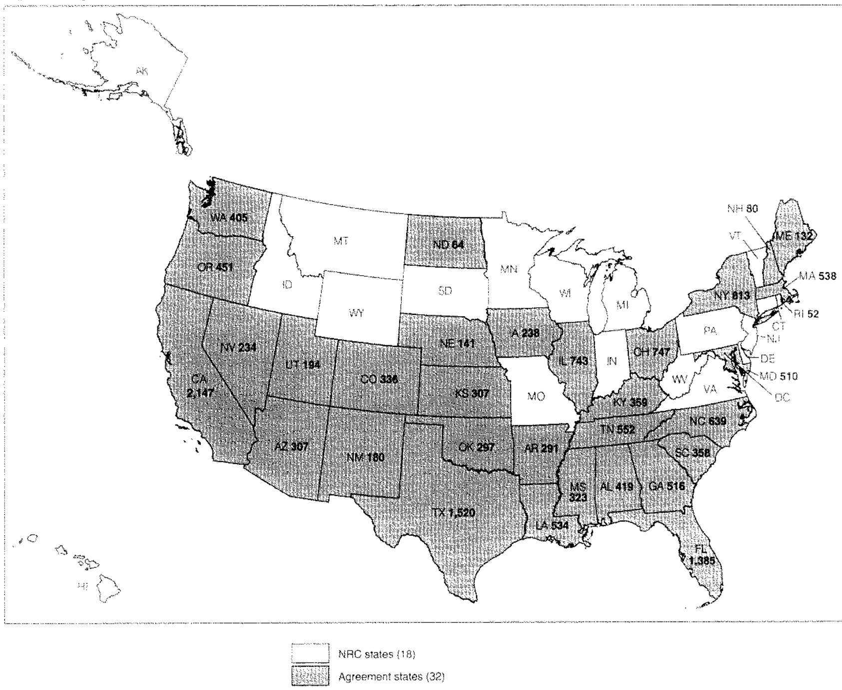
Agreement states (32)

Sources: NRC license tracking system and GAO survey of agreement states.

Notes: NRC regulates specific licensees on federal facilities in agreement states.

NRC also regulates 5 specific licensees in Guam, 120 specific licensees in Puerto Rico, and 7 specific licensees in the U.S. Virgin Islands.

Figure 2: Agreement State Regulated Specific Licenses as of December 31, 2002



Sources: NRC license tracking system and GAO survey of agreement states.

Our analysis of NRC's license tracking system and responses to our survey of agreement states indicates that sealed sources for medical uses comprise the largest portion of specific licenses issued (see table 1).

Table 1: Number of Specific Licenses Issued By Use in the United States as of December 31, 2002

State	Medical	Measuring systems	Industrial radiography	Well logging	Irradiators-large	Irradiators-small	Other	Total
Alabama	153	185	26	3	0	2	63	**432**
Alaska	10	21	7	0	0	1	5	**44**
Arizona	NA	NA	NA	NA	NA	NA	NA	**318**
Arkansas	118	128	10	6	1	4	29	**296**
California	655	799	40	18	9	26	640	**2,187**
Colorado	85	166	12	10	0	4	79	**356**
Connecticut	69	38	3	0	0	3	63	**176**
Delaware	19	16	1	1	0	2	15	**54**
District of Columbia	18	6	0	0	1	3	12	**40**
Florida	866	367	20	8	2	24	111	**1,398**
Georgia	267	175	13	1	2	5	66	**529**
Guam	2	3	0	0	0	0	0	**5**
Hawaii	21	25	3	1	0	1	5	**56**
Idaho	20	36	0	0	0	0	12	**68**
Illinois	273	338	18	7	4	8	125	**773**
Indiana	144	86	4	0	0	1	39	**274**
Iowa	67	136	6	0	0	5	27	**241**
Kansas	130	142	12	20	0	2	13	**319**
Kentucky	158	180	6	8	0	3	11	**366**
Louisiana	NA	NA	NA	NA	NA	NA	NA	**548**
Maine	47	57	4	0	0	3	22	**133**
Maryland	226	140	2	0	7	19	169	**563**
Massachusetts	120	180	7	0	2	13	239	**561**
Michigan	250	168	7	4	1	7	64	**501**
Minnesota	56	49	5	0	1	5	38	**154**
Mississippi	118	157	21	5	1	6	21	**329**
Missouri	136	84	7	0	0	3	56	**286**
Montana	16	38	1	0	0	2	11	**68**
Nebraska	50	66	4	0	3	4	19	**146**
Nevada	86	130	5	1	0	3	13	**238**
New Hampshire	27	39	2	0	1	1	13	**83**
New Jersey	239	98	5	0	7	13	128	**490**
New Mexico	44	99	9	11	2	5	22	**192**
New York	512	268	25	2	2	4	38	**851**

(Continued From Previous Page)

State	Medical	Measuring systems	Industrial radiography	Well logging	Irradiators-large	Irradiators-small	Other	Total
North Carolina	266	235	17	1	4	5	124	**652**
North Dakota	13	37	4	4	0	3	5	**66**
Ohio	341	274	22	4	2	5	128	**776**
Oklahoma	111	107	27	20	0	8	51	**324**
Oregon	88	262	8	0	0	4	97	**459**
Pennsylvania	296	215	11	4	1	24	145	**696**
Puerto Rico	65	35	3	0	2	3	12	**120**
Rhode Island	22	16	6	0	0	1	9	**54**
South Carolina	149	145	22	0	3	1	50	**370**
South Dakota	17	16	0	0	0	0	7	**40**
Tennessee	261	167	26	1	2	10	99	**566**
Texas	672	468	102	54	7	19	241	**1,563**
Utah	38	108	10	7	1	2	35	**201**
Vermont	13	10	0	0	0	2	7	**32**
U.S. Virgin Islands	2	4	0	0	0	0	1	**7**
Virginia	126	155	12	2	1	6	57	**359**
Washington	110	199	10	0	0	2	98	**419**
West Virginia	66	89	2	3	0	0	15	**175**
Wisconsin	106	88	9	0	1	7	52	**263**
Wyoming	17	40	2	3	0	0	10	**72**
Total	**7,781**	**7,090**	**578**	**209**	**70**	**284**	**3,411**	**20,289**

Sources: NRC license tracking system and GAO survey of agreement states.

Notes: NA=not available.

Does not include licenses issued for naturally occurring or accelerator-produced radioactive materials in NRC regulated states. Twenty-nine of the 31 agreement states responding to our survey do not distinguish between materials regulated under the Atomic Energy Act of 1954 and naturally occurring or accelerator-produced radioactive materials in their licensing actions.

Data for Arizona and Louisiana includes only the total number of licensees.

Fixed and portable gauges used in industry to measure density, moisture content, thickness, and so forth, are the next most prevalent use of sealed sources, with nearly 7,100 specific licenses issued nationwide. Over 570 specific licenses have been issued for industrial radiographers. In addition, there are 70 large irradiators (containing high levels, between 10,000 and 15 million curies, of cobalt-60) across the United States used for the sterilization of food and medical products, and 284 smaller irradiators (containing less than 10,000 curies of, in most cases, cesium-137 and cobalt-60) used in hospitals and other facilities for sterilization of smaller

products, such as units of blood. The remaining specific licenses in the United States are issued for a variety of purposes, including, among other things, manufacturing and distribution of smoke detectors (containing small amounts of americium-241), academic research, and disposal of radioactive waste.

NRC Has Had Difficulty Finding Owners of Generally Licensed Devices

While data exist on the numbers and locations of specific licenses in the United States, complete data are not available on the numbers of general licenses. In most cases general licensees are not required to apply to NRC or an agreement state for a license to possess and use a device. Therefore, in the past, data on general licensees have come from manufacturers of generally licensed devices that are required to report quarterly to NRC or the agreement states the names of customers purchasing generally licensed devices. According to NRC, approximately 40,000 general licensees possess an estimated 600,000 generally licensed devices in the United States. Although general licensees are required to follow NRC's regulations, they traditionally have little contact with NRC. Mishandling and improper disposition of generally licensed devices has, on occasion, resulted in limited radiation exposure to the public and, in some cases, entailed expensive investigation, cleanup, and disposal activities. For example, two incidents occurred in New Jersey in 1997 involving luminous exit signs containing tritium. In May 1997, a 14-year old removed three tritium exit signs from a demolition site near his home and opened one sign exposing himself to radioactive material and contaminating his home. In October 1997, a patient at a state-run psychiatric hospital broke a tritium exit sign. While no injuries resulted, the state spent more than $200,000 cleaning up the hospital and disposing of the more than sixty barrels of radioactive waste—primarily contaminated carpeting, furniture, bedding, and other debris—from the incident.

NRC amended its regulations effective February of 2001, to, among other things, better enable NRC to verify and track the location, use, and disposition of generally licensed devices. NRC focused its efforts to improve accountability over generally licensed devices on a small subset of devices that were determined to be of higher risk. The amended regulations include a requirement for general licensees to register with NRC devices that contain certain levels of radioactive material.[10] General licensees would be charged $450 to cover the costs of the registration program.

Beginning in April 2001, NRC mailed registration forms to about 2,800 of its general licensees.[11] As of May 2003, approximately 61 percent of them had responded. Twenty-eight percent of the registration forms were returned as undeliverable and the remaining 11 percent were not returned by the general licensee, a response rate significantly lower than NRC expected. According to NRC, a significant amount of the submitted information is incomplete or inaccurate, requiring additional follow up that was not anticipated. To help increase the response rate, phone calls are being made in advance to locate general licensees before registration forms are sent to ensure the responsible individuals at the correct addresses receive them. In addition, NRC has contracted with a private investigation firm to help find general licensees whose addresses in the database are incorrect.

Twenty-five of the 31 agreement states that responded to our survey said that they require registration of some or all generally licensed devices. Seventeen of these states were able to provide us with data on the number of generally licensed devices they regulate. These 17 states estimate that approximately 17,000 generally licensed devices are used in their jurisdictions.

[10] 10 C.F.R. § 31.5(c)(13). Registration is required for levels equal to or greater than 10 millicuries of cesium-137, 0.1 millicuries of strontium-90, 1 millicurie of cobalt-60, or 1 millicurie of any transuranic element (elements with atomic numbers higher than uranium).

[11] This registration effort did not include the agreement states because the agreement states are not required to adopt compatible regulations requiring registration of generally licensed devices until February 2004. Once all agreement states have adopted rules compatible to NRC's regulations, NRC says that it is considering coordinating with them to implement a national level database that will incorporate data from agreement states and NRC regulated states.

Over 1,300 Devices Containing Sealed Sources Have Been Reported Lost, Stolen, or Abandoned Since 1998

Since 1998, there have been more than 1,300 incidents where devices containing sealed sources have been reported lost, stolen, or abandoned in the United States, an average of about 250 per year. The majority of these lost devices were subsequently recovered. Both NRC and DOE recognize the importance of not only determining how many sealed sources are present in the United States, but also which sealed sources pose the greatest risk if used in a dirty bomb. NRC and DOE are working together to categorize sealed sources by their level of risk. However, NRC's and DOE's efforts have not, to date, addressed sealed sources in the agreement states.

Majority of Lost and Stolen Sealed Sources Subsequently Recovered and Represented Little Risk to the Public

Analysis of NRC's Nuclear Materials Events Database indicates that, between 1998 and 2002, there were over 1,300 incidents of lost, stolen, and abandoned sealed sources. These losses averaged about 250 per year. Many of these incidents involved stolen portable gauges that are used to measure the moisture content and density of soils, concrete, or asphalt on construction sites. By themselves, these gauges contain low amounts of radioactive material and pose relatively little risk to the public. Portable gauges are most often stolen from construction sites or from vehicles such as pickup trucks. According to NRC and agreement state officials, individuals stealing gauges are usually unaware that they contain radioactive material, and they often abandon or return them once discovering their contents. Nevertheless, responding to these incidents takes time and resources. Well logging sources also account for a relatively large number of lost and abandoned sources. One major oil services company accounts for over 30 of the 132 total well logging sources abandoned since 1998. These sources contain several curies of americium-241 and cesium-137. These losses usually consisted of a sealed source becoming lodged down a well and subsequently abandoned. The well is filled with concrete and a marker is attached warning of the presence of radioactive materials. In addition, sealed sources are occasionally abandoned when companies owning them go bankrupt.

According to NRC, most sealed sources that are lost, stolen, or abandoned are subsequently recovered. In the past 5 years, few incidents have occurred involving what NRC considers high-risk sealed sources. For example, in March 1999, an industrial radiography camera containing over 88 curies of iridium-192 (a quantity NRC considers to be of concern) was stolen from a trailer at the radiographer's home in Florida. The Florida radiation control program, local law enforcement, and the Federal Bureau of Investigation conducted an investigation, but never recovered the sealed

source. According to NRC, the iridium-192 in the sealed source has now decayed to the point where it is no longer a high risk to the public.

Another example of lost or stolen sealed sources took place in a North Carolina hospital in March 1998. During a quarterly inventory of a hospital's sealed sources, it was discovered that 19 sealed sources were missing, containing an aggregate of over 600 millicuries of cesium-137—a highly dispersible radioactive material. These sources included 18 cesium-137 sealed sources—which had been locked in a safe at the time of the disappearance—and a new cesium-137 sealed source still stored in its shipping container. The North Carolina radiation control program, NRC, DOE, and the Federal Bureau of Investigation conducted an extensive joint investigation. The investigation included air and ground searches using radiation detection equipment. However, the sealed sources were not recovered and a conclusion about the cause of the incident was not reached.

NRC's and DOE's Efforts to Categorize Sealed Sources of Greatest Concern Does Not Include Sealed Sources in Agreement States

The working group established by the Secretary of Energy and the Chairman of NRC in June 2002 was also tasked with determining which radioactive materials pose the greatest risk if used in a dirty bomb. Their analysis was to provide a relative ranking of the degree of risk posed by specific materials as a basis on which initial judgments can be made regarding specific protective measures to be developed for these materials.

Using experts from DOE's Sandia National Laboratory, the task force developed a methodology to systematically evaluate radioactive materials for a dirty bomb. Researchers at Sandia considered the potential dispersability of radioactive materials, the number of locations possessing the material, the quantity of material possessed at each facility, and the protective measures already applied to the material. The combination of these factors yielded a "hazard index," which serves as an expression of relative concern. Specific radioactive materials were rated high, medium, low, or very low, depending upon the degree of health risk posed for their use in a dirty bomb.[12] The analysis focused on the potential health effects of

[12]See U.S. Department of Energy and U.S. Nuclear Regulatory Commission, *Radiological Dispersion Devices: An Initial Study to Identify Radioactive Materials of Greatest Concern and Approaches to Their Tracking, Tagging, and Disposition*, (Washington, D.C., May 2003). The specific radioactive materials identified as highest priority for increased protection in the near term have not been listed in the report. This information is "For Official Use Only."

the use of radioactive materials in a dirty bomb and did not explicitly address the psychological and economic consequences. According to an NRC official, no specific data exists regarding how the public would react to a dirty bomb, which complicates efforts to analyze its psychological consequences.

The working group's analysis included materials under an NRC license and DOE's control in the United States, excluding nuclear weapons materials, radioactive materials in nuclear power plants, spent fuel, and other radioactive waste. DOE's and NRC's report, however, did not consider sealed sources held by the approximately 15,000 specific licensees in the agreement states. Although the agreement states and NRC have similar types of licensees, agreement states often have greater numbers of licensees with certain types of sealed sources than NRC-regulated states. For example, our survey of agreement states indicates that Texas has more well logging specific licensees than any other state.[13] In addition, states exclusively regulate the use of naturally occurring and accelerator produced radioactive materials. Agreement state officials told us that any consideration of the risks presented by sealed sources needs to include all materials regulated by NRC and the agreement states because the psychological and economic consequences of a dirty bomb are likely to be similar whether the radioactive material is naturally or artificially produced. NRC plans to work with the states to implement follow-up actions based on the recommendations in the DOE/NRC report. Vulnerability studies have been initiated to identify security vulnerabilities and appropriate security enhancements. Scenarios involving the aggregation of sources in a single location will be considered. In addition, methods for improved tracking of the locations of sources will be developed.

[13]Well logging is a process that uses sealed sources and/or unsealed radioactive materials to determine whether a well, drilled deep into the ground, contains minerals, such as coal, oil, and natural gas.

Weaknesses Exist in Federal and State Controls Over the Security of Sealed Sources

Weaknesses exist in federal and state controls over the security of sealed sources.[14] Security for devices containing sealed sources varied among facilities we visited in 10 states. In addition, NRC's licensing process to obtain sealed sources presents a potential security weakness, namely that approved applicants may purchase sealed sources as soon as a new license is issued by mail. Because the process assumes that the applicant is acting in good faith, it is possible that sealed sources can be obtained for malicious intent. It can take as long as 12 months before NRC conducts its first inspection of the sealed source holder, potentially allowing sealed sources to be obtained and used maliciously without NRC's knowledge.

Security at Facilities Using Sealed Sources Varies

During visits to licensees, regulated by both NRC and agreement states, we found a varied level of security provided to sealed sources. A medical device manufacturer we visited in an agreement state had extensive security measures in place to protect sealed sources. For example, a heavy iron fence surrounds the building and guards are on duty to monitor the facility 24 hours per day, 7 days per week. For shielding and security, the concrete walls and ceiling containing the radioactive materials are more than 6 feet thick. All areas housing materials have electronic locks requiring a 4-digit code and card access. Visitors must be pre-arranged and escorted at all times. Background and drug checks are conducted on all personnel before hiring. Once hired, they are provided with varying degrees of building access, depending upon their duties. Eighteen staff members are fully trained in emergency response for hazardous materials and every employee is required to complete a 3-hour training course on radioactive materials and refresher training sessions are held frequently. Following the events of September 11, 2001, the company examined risks for the facility and established an in-house task force to develop scenarios of potential terrorist attacks. To test the company's security and employees' preparedness, the company's chief executive officer had a helicopter land, unannounced, on the roof of one of the company's buildings. Following this drill, emergency plans were developed that were integrated with the national Homeland Security Advisory System. For example, whenever the national threat level is raised to orange, the facility's front gates are closed

[14]As used in this report, *security* refers to measures to prevent unauthorized access to, loss, and/or theft of sealed sources. *Safety* refers to measures intended to minimize the likelihood of an accident with sealed sources and, should such an accident occur, to mitigate its consequences.

and locked at all times. If the threat level were ever increased to red, no visitors would be allowed. Furthermore, the company has entered an agreement with the local police to hire armed off-duty police to provide additional security for the facility should the national threat level be raised to red.

Extensive security measures were also present at a facility we visited in an agreement state that manufactures portable moisture density gauges.[15] Sealed sources, shipped to the manufacturer for installation in moisture density gauges, are immediately placed in a shielded basement storage room that is kept locked at all times. Only three staff members have keys to access the room. Entrances to the manufacturing facility are kept locked at all times, with an alarm system activated after closing time. Visitors must be escorted during visits. Finally, the company has initiated a computerized "cradle to grave" tracking system where all sealed sources installed in moisture density gauges are tracked from manufacture, use, and eventual disposal.

In the course of visits to a medical licensee, we observed poor security practices with sealed sources. For example, during a visit to a hospital in an agreement state, we were told that sealed sources, including strontium-90, cesium-137, and iridium-192, were securely stored in a room equipped with an electronic lock with limited access. Later, during a tour of the hospital, we found the room unlocked, unattended, and the door propped open. The hospital official explained that this practice was very unusual; he locked the room door after inspection and continued the tour. Shortly thereafter, we passed the room for a second time. Again, the room was unlocked, unattended, and the door propped open. The storage room was in close proximity to the hospital's laundry and maintenance facility, which is accessible to any hospital employee. In addition, an entry to the hospital from the outside was also nearby, and this entrance was not guarded nor equipped with radiation detection equipment to notify security if any sealed sources were being removed or stolen.

We also saw potential vulnerabilities at industrial radiography licensees we visited in agreement states. Industrial radiographers use high radioactivity iridium-192 sources to produce an image on photographic film to inspect

[15] Moisture density gauges are commonly used to measure density of asphalt and concrete surfaces and soil moisture content during road construction. See appendix II for a complete descriptions of radioactive devices.

metal parts and welds for defects. These devices are very portable because they are often used at remote locations. The devices are also subject to limited security at the locations we visited—primarily a series of padlocks on storage cases for the device. Personnel are not required to have background checks and training was historically only on-the-job. Most agreement states now require classroom training and testing to enhance radiographers' knowledge and skills. One industrial radiographer we visited added extra security measures consisting of a motion detector alarm system—monitored by the local police—and an extra lock to the gate of the storage room at its facility. However, this additional security would not prevent the theft of the sealed source when the device is being used in the field or at a customer's facility. This industrial radiographer had taken additional steps to train his workers to be aware of security threats and required—even before it was required by NRC and agreement state regulations—for two people to be present whenever the sealed source was being used.

Current Licensing Process Leaves Sealed Sources Vulnerable

To qualify for a specific license to use sealed sources, an applicant must demonstrate that their use of sealed sources will meet safety requirements set forth in NRC regulations or in comparable agreement state regulations (if the license applicant is located in an agreement state). NRC requires license applications to include information on, among other things, types of sealed sources that will be used, details of the applicant's radiation protection program for workers dealing with sealed sources, and qualifications of users of sealed sources. NRC reviews this information for adherence to procedures and criteria documented in NRC licensing guidance.[16] If the application meets approval criteria, a license is issued.

NRC licensing procedures do not require inspection of licensee facilities before the issuance of a license. Instead, NRC performs initial inspections no later than 12 months after issuance of a license.[17] However, as pointed out by an agreement state official, a licensee can purchase sealed sources as soon as a license has been acquired by mail. As a result, licensees may purchase sealed sources legally without first verifying that they will use the

[16] NRC publishes guidance for specific license applicants that outlines procedures for licensing the use of sealed sources. See U.S. Nuclear Regulatory Commission, *NUREG-1556—Consolidated Guidance about Materials Licenses*, (Rockville, Maryland: Nov. 2001).

[17] Chapter 2800 of NRC's Inspection Manual contains guidance for inspections of specific licensees with sealed sources.

material as intended. Several agreement states have developed methods to verify the legitimacy of potential licensees. For example, one program we visited conducts prelicensing inspections. Another state program hand-delivers licenses at the end of the application process. An agreement state official explained that pre-licensing inspections and hand delivery enabled regulators to establish authenticity of the prospective licensee and whether information provided in the application is indeed valid.

NRC and Agreement States Generally Ensure Safe Use and Handling of Sealed Sources

NRC conducts periodic evaluations of NRC regional materials programs and agreement state radiation control programs to ensure that public health and safety is adequately protected. Accidents and injuries resulting from the use of sealed sources are relatively few. For example, analysis of NRC's Nuclear Materials Events Database and responses to our survey of the agreement states indicates that in fiscal year 2002, only 25 of the approximately 20,000 licensees in the United States reported radiation exposures in excess of regulatory limits. In addition, according to NRC, there were only 32 reported accidents in fiscal year 2002 involving medical use of sealed sources out of tens of thousands of medical procedures conducted.

To evaluate the performance of its and agreement states' programs, NRC developed the Integrated Materials Performance Evaluation Program, which uses several performance indicators in assessment of program effectiveness, including timeliness and quality of licensee inspection, program staffing and training, licensing activity, and response to incidents and allegations. Officials from NRC and agreement states participate in these periodic evaluations. During these evaluations, NRC and agreement state officials review program documentation and interview officials with the state or regional program to assess the program's performance. When the results of each performance indicator have been determined, a final report is issued.[18] Agreement state or NRC regional programs can be evaluated as:

- adequate to protect the public health and safety,
- adequate but needs improvement, and

[18]The final determination of program adequacy is made by a management review board at NRC, which consists of NRC executives and a nonvoting representative of the agreement states.

- inadequate to protect public health and safety.

Figure 3 outlines the results of the most recent reviews of agreement state and four NRC regional programs.

Figure 3: Results of Integrated Materials Performance Evaluation Program Reviews

State program or NRC Region	Date	Status of inspections programs	Technical quality of inspections	Technical staffing and training	Technical quality of licensing actions	Response to incidents and allegations	Final determination of program adequacy
Alabama	04/02	○	○	○	○	○	Adequate
Arizona	03/02	○	○	○	○	○	Adequate
Arkansas	03/98	○	○	○	○	○	Adequate
California	10/99	○	○	○	○	○	Adequate
Colorado	02/01	○	○	○	○	○	Adequate
Florida	02/03	○	○	○	○	○	Adequate
Georgia	04/00	○	○	○	○	○	Adequate
Illinois	03/01	○	○	○	○	○	Adequate
Iowa	08/99	○	○	○	○	○	Adequate
Kansas	04/02	○	○	◒	○	○	Adequate
Kentucky	07/00	◒	○	○	○	○	Adequate
Louisiana	03/00	○	○	○	○	○	Adequate
Maine	11/02	○	○	○	○	○	Adequate
Maryland	03/99	○	○	○	◒	○	Adequate
Massachusetts	06/02	○	○	○	○	◒	Adequate
Mississippi	05/01	○	○	○	○	○	Adequate
Nebraska	09/02	○	○	○	○	○	Adequate
Nevada	09/01	●	○	◒	○	◒	Adequate but needs improvement. Heightened oversight
New Hampshire	06/01	●	○	◒	○	○	Adequate but needs improvement. Heightened oversight
New Mexico	06/01	○	○	○	○	○	Adequate
New York	07/02	◒	○	○	○	◒	Adequate
North Carolina	09/00	○	○	○	○	○	Adequate
North Dakota	04/99	○	○	○	○	○	Adequate
Ohio	05/01	○	○	○	○	○	Adequate
Oklahoma	07/02	○	○	○	○	○	Adequate
Oregon	08/02	○	○	○	○	○	Adequate
Rhode Island	11/02	●	○	○	○	○	Adequate but needs improvement. Heightened oversight
South Carolina	07/99	○	○	○	○	○	Adequate
Tennessee	08/00	●	●	○	○	◒	Adequate but needs improvement. Heightened oversight
Texas	08/01	○	○	○	○	○	Adequate
Utah	11/98	○	○	○	○	○	Adequate
Washington	09/99	○	○	○	○	○	Adequate
NRC region I	03/01	○	○	○	○	○	Adequate
NRC region II	03/02	○	○	○	○	○	Adequate
NRC region III	03/99	○	○	○	○	○	Adequate
NRC region IV	04/99	○	○	○	○	○	Adequate

○ Satisfactory
◒ Satisfactory with recommendations for improvement
● Unsatisfactory

Source: NRC.

NRC's most recent reviews of the 32 agreement states and NRC regional programs, dating back to 1998, found that all programs are adequately protecting public health and safety. Of the last 35 program reviews, 31 programs were found adequate to protect public health and safety—the highest evaluation. Four programs were found "adequate but needs improvement" and were placed on "heightened oversight."[19] A program placed on heightened oversight must follow a plan to improve performance or it will be placed on probation for failing to correct programmatic deficiencies. Furthermore, NRC reserves the right to suspend a state's agreement if the state does not comply with one or more of the requirements of the Atomic Energy Act of 1954.

The Integrated Materials Performance Evaluation Program is intended to ensure that the NRC and the agreement states adequately protect the health and safety of the public in accordance with NRC standards. For example, in February 2003, the Rhode Island program was found "adequate but needs improvement." As a result of its evaluation, the Rhode Island program was placed on heightened oversight and was instructed to follow a detailed plan to improve performance, which includes NRC monitoring of progress through bimonthly teleconferences. In addition, the Rhode Island program must periodically submit a progress report to NRC. The review team found that a deficiency in staffing and training had led to Rhode Island's performance problems. Therefore, as part of the plan to improve performance, Rhode Island was instructed to address staffing and training concerns. In November 2003, a follow-up review will be conducted to establish whether the program has improved enough to remove it from heightened oversight status.

The review program also encourages states and NRC regions to learn good practices from one another. For example, an NRC official recommended that Florida be cited for a good practice for its in-house training efforts for the program's staff, including the creation of a new "training coordinator" position. As a result of participation by an Ohio official during Florida's last evaluation, Ohio's program decided to hire a training coordinator. Furthermore, because review results are available to the public and a good practices report is periodically distributed to all agreement states and NRC regions, all programs have access to the good practices of other programs.

[19] States under "heightened oversight" as of May 31, 2003, are Rhode Island, Nevada, and New Hampshire. Tennessee was removed from "heightened oversight" based on an October 2001 follow-up review.

The report not only shares the good practices, but also the reasons for poor performance. Agreement state and NRC regional programs can take action to improve performance by examining the strengths and weaknesses of other programs.

NRC Efforts to Improve Security over Sealed Sources Have Been Limited and Disagreement Exists over the Appropriate Role of the States

Efforts undertaken by NRC and agreement states to strengthen the security of sealed sources for medical, industrial, and research use have only, to date, required large irradiator facilities to take specific actions. Additional orders to licensees that possess high-risk sealed sources are expected to follow. NRC and agreement states disagree over the appropriate role of the states in efforts to improve security. NRC intends to develop and implement all additional security measures on licensees with sealed sources, including those licensed by agreement states. However, 82 percent of agreement states responding to our survey feel they should be responsible for inspecting and enforcing security measures for sealed sources in their states under their authority to ensure public health and safety.

NRC's Security Efforts Have Not Focused on Sealed Sources

Since the events of September 11, 2001, NRC efforts have focused on issuing advisories and orders for nuclear reactor and nuclear fuel licensees and implementing changes within NRC to streamline its security responsibilities. Specifically, NRC has issued over 30 advisories and 20 security orders requiring action to nuclear power plants, decommissioning power reactors, fuel cycle facilities, and spent fuel facilities.[20] Between November and December 2001, NRC's Office of Investigations visited 80 nuclear facilities, law enforcement agencies, and first responders nationwide to interview officials and review records to identify potential terrorist risks. NRC forwarded potential leads to the Federal Bureau of Investigation. In addition, NRC has revised the "design basis threat" for nuclear power plants—the largest reasonable threat against which a regulated private guard force should be expected to defend under existing law—and issued a corresponding order in April 2003 requiring power

[20] *Advisories* are non-public, rapid communications from NRC to its licensees that provide information obtained from the intelligence community or law enforcement agencies on changes to the threat environment, and guidance for licensees to take specific actions promptly to strengthen their capability against the threat. *Security orders* contain requirements for licensees to implement interim compensatory security measures beyond that currently required by NRC regulations and as conditions of licenses.

plants to implement additional actions to protect against sabotage by terrorists and other adversaries. NRC also made a series of internal administrative changes, such as consolidating the agency's security responsibilities in establishing an Office of Nuclear Security and Incident Response,[21] which includes a Threat Assessment Team responsible for working directly with the Central Intelligence Agency and the Federal Bureau of Investigation on security issues. The Office of Nuclear Security and Incident Response also works with the Department of Homeland Security and other agencies concerned with terrorism to assess and respond to potential threats. In an effort to more effectively communicate and respond to threats, NRC developed a Threat Advisory and Protective Measures System[22] based on the national Homeland Security Advisory System, and increased staffing at its 24-hour Emergency Operations Center. NRC also conducted a review of information available to the general public on the NRC Web site for potential security risks.

Efforts to strengthen the security of sealed sources for medical, industrial, and research use—by both NRC and agreement states—have been limited. Since September 11, 2001, NRC has issued a total of six advisories urging licensees to ensure security of sources and advising them to be more aware of the possibility of theft and sabotage.[23] Licensees were also advised to double-check shipping documents and inform local police authorities of their possession of sealed sources. On June 5, 2003, NRC issued its first security order for large irradiator facilities—70 facilities nationwide that expose products, such as medical supplies, to radiation for sterilization—that requires licensees to take action to strengthen security. The decision to select irradiators first has been questioned by agreement state officials and licensees, as they feel other uses of sealed sources pose a higher risk. For example, 93 percent of agreement states responding to our survey identified industrial radiographers as of greater concern. Reasons for this may include that the sealed sources in these devices are portable, have high

[21]The Office of Nuclear Security and Incident Response was established in April 2002 and consists of two divisions – the Division of Nuclear Security and the Division of Incident Response Operations. It is responsible for the agency's security, safeguards, and incident response efforts and to serve as a point of contact and counterpart to the Department of Homeland Security and other federal agencies. In this role, the Office of Nuclear Security and Incident Response participates in a number of interagency working groups and committees that address issues relating to terrorism, information sharing, and planning.

[22]NRC established this system in response to Homeland Security Presidential Directive 3.

[23]There were a total of seven advisories, one of which was a correction to a prior advisory.

radioactivity, and are widely available (over 570 licensees in the United States). Although irradiator facilities contain larger amounts of radioactive material than industrial radiographers, they are specially designed to include thick concrete and steel walls, security interlocks, and other protective equipment to protect against radiation exposure. In addition, the irradiator facilities we visited had taken the initiative to implement supplementary security measures, such as installing motion detectors, more extensive security alarms and monitoring, and employee identification badges. Other uses identified by agreement states officials in our survey as requiring stricter regulation include portable gauges and well-logging devices—over 4,600 and over 200 licensees nationwide, respectively.

Transportation was also identified as needing additional security. Although most agreement states surveyed indicated that the Department of Transportation's (DOT) regulations are adequate to ensure safe transportation of sealed sources, 81 percent of them identified weaknesses in current regulations and 77 percent indicated that communications and coordination needs to be improved between their state program and DOT. Some DOT officials we spoke with disagreed that sealed sources were particularly vulnerable during transportation. However, one DOT official noted that large quantities of iridium-192 are regularly shipped to the United States from Europe and South America using regular commercial freight services. Such sources are shipped in stainless steel transport kegs that require no special tools or equipment to open. Once loaded with up to 10,000 curies of iridium-192, the transport keg weighs only 150 to 200 pounds. While this official believed that, overall, security is sufficient during transport, he told us that at certain phases such shipments could be vulnerable to terrorist diversion.

NRC and the agreement states have formed a materials security working group to develop and issue new security orders by the end of the year for approximately 2,100 licensees—located throughout the United States—that have been determined to be of the greatest risk based upon NRC's and DOE's work to categorize sealed sources. When these orders are issued, affected licensees will have a certain specified time period to comply with the order and implement required security measures. At the end of this period, licensees will be subject to inspections to ensure compliance and face enforcement actions if actions have not been taken.

Agreement states' efforts to strengthen the security of sealed sources have focused primarily on facilitating NRC actions, such as forwarding NRC

advisories, increasing attention on security when conducting inspections and license reviews, and coordinating with local law enforcement and first responders to develop emergency response procedures. Eighty-six percent of agreement state officials responding to our survey indicated that they are adequately addressing post-September 11, 2001, heightened security concerns involving malicious use of radioactive material.

NRC and the Agreement States Disagree over Development and Enforcement of Additional Security Requirements

The Atomic Energy Act of 1954 authorizes NRC to issue rules, regulations, or orders to promote the common defense and security, while granting agreement states the authority to ensure public health and safety.[24] Following the events of September 11, 2001, NRC determined that security-related efforts for all medical, industrial, and research licensees—including those licensed by agreement states—should be the responsibility of NRC under its common defense and security authority. However, 82 percent of agreement states responding to our survey noted that they want to have responsibility for inspection and enforcement of security measures for sealed sources under their authority to ensure public health and safety. Agreement states already enforce NRC's existing security regulations under this authority. In addition, 74 percent of agreement states responding to our survey indicated they could effectively respond to a radiological incident with their current resources.

Individual commissioners at NRC have expressed concern with budget shortfalls many states are currently experiencing. These commissioners said that states experiencing budgetary difficulties may not be able to assume additional responsibilities and that it may impact their program's performance. When asked whether their state had sufficient resources to support new efforts, 60 percent of agreement states responding to our survey indicated they would need additional resources.[25] However, officials from organizations representing agreement states and non-agreement states have met with NRC and advised NRC that, although many states are

[24]NRC's regulations require licensees to secure licensed materials that are stored in controlled or unrestricted areas from unauthorized removal or access and to control and maintain constant surveillance of licensed material that is not in storage and is in a controlled or unrestricted area. 10 C.F.R. §§ 20.1801, 20.1802.

[25]Approximately 20 percent of agreement state officials responding to our survey indicated that they are having difficulty retaining sufficient and/or qualified personnel to effectively regulate sealed sources. Nevertheless, NRC has determined that all agreement state programs are adequately protecting public health and safety.

facing budget cuts, funding of the radioactive materials programs in these states have largely been stable and the programs have been able and will likely be able to adequately fulfill their responsibilities.

According to our discussions with NRC officials, NRC is also facing budget and staffing constraints, largely as a result of its dependence upon fees from the licensees it regulates—only 20 percent of the total sealed sources licensees nationwide—for funding of its sealed source licensing and inspection activities. As more states become agreement states, NRC has fewer licensees to support its licensing and inspection programs.[26] To address the potential effect this reduction in funding may have on its licensing and inspection programs, NRC and the agreement states have entered into a partnership—called the National Materials Program—to better share the responsibility for protecting public health and safety. Since the agreement states regulate about 80 percent of the nation's sealed source licensees, the National Materials Program allows them to participate more actively in the development of regulations and guidance, particularly in areas where they possess expertise. For example, Texas, an agreement state, regulates more well logging specific licensees than exist in all NRC-regulated states. Thus, according to NRC officials, Texas could take the lead in developing any new public health and safety regulations for well loggers. Both NRC and the agreement states are currently conducting pilot projects to determine how the National Materials Program can and will work. In addition, states remain solely responsible for regulating certain radioactive materials, such as naturally occurring radioactive material like radium and material produced in particle accelerators, increasing the importance of federal and state cooperation in developing and implementing additional safety and/or security measures. NRC and the agreement states are continuing to work cooperatively to develop information on how responsibilities can be shared under the National Materials Program.

NRC officials said that NRC lacks sufficient staff to conduct inspections of all licensees expected to receive security orders—large irradiator facilities and approximately 2,100 licensees that NRC has identified as presenting the greatest risk. To mitigate this staffing shortage, NRC intends to enter

[26]NRC is required by the Energy and Water Development Appropriations Act, 2001 (P.L. 106-377) to recover 94 percent of its budget through fee recovery. As the number of NRC licensees decreases with an increasing number of agreement states, fees paid by NRC's licensees have increased in order to support NRC's regulatory program.

into contracts with agreement states or independent contractors to assist in carrying out these inspections. According to agreement state officials we spoke with, however, agreement states may be reluctant to participate in these efforts if they have had no role in developing the additional security requirements or are not provided additional funding. NRC would remain responsible for taking appropriate enforcement action for any security violation found during these inspections. According to NRC, although final details regarding funding have yet to be determined, NRC anticipates increasing its licensees' fees and using funds NRC has received from emergency supplemental appropriations to cover costs associated with additional security.

Conclusions

The terrorist attacks of September 11, 2001, have changed the focus of radioactive sealed sources regulation. Where NRC and the agreement states previously concentrated on ensuring the safe and effective use of sealed sources, they must now increasingly consider how to prevent terrorists from obtaining and using the material. Efforts to improve controls over sealed sources face significant challenges, especially how to balance the need to secure these materials while not discouraging their beneficial use in academic, medical, and industrial applications. The first step to improve security is to conduct a threat assessment that would identify sealed sources most likely to be used in a terrorist attack and the consequences of such an attack. Defining the types of sealed sources that are of the greatest concern will allow federal and state efforts to be appropriately prioritized. NRC's and DOE's current efforts to categorize sealed sources by the greatest amount of risk and their efforts to establish a national-level tracking system for the highest risk sealed sources are commendable. However, these efforts could be strengthened by involving the agreement states, which regulate 80 percent of the nation's radioactive materials licensees, in determining risk. In addition, these efforts could be further strengthened by determining the economic consequences of a dirty bomb and how to effectively mitigate any resulting psychological consequences. In addition, NRC's current regulations leave sealed sources at risk of malicious use. Modifying its regulations to eliminate general licensing of devices containing sealed sources could improve accountability, potentially reducing the number of sources that are lost, stolen, or abandoned. Furthermore, modifying NRC's licensing and/or inspection process to verify—before a licensee purchases radioactive material—that it will be used as intended may increase the security of sealed sources.

The President's National Strategy for Homeland Security recognizes the critical importance of integrating federal, state, local, and private sector efforts to prepare and respond to terrorist attacks, including those using sealed sources. The initial responsibility, however, falls upon state and local governments and their organizations—such as police, fire departments, emergency medical personnel, and public health agencies—which will almost invariably be the first responders to any terrorist event involving sealed sources. Because of state and local governments' role in responding to incidents—in addition to the fact that the federal government lacks authority over naturally occurring and accelerator produced radioactive material—it is critical to involve state and local governments in the development and implementation of additional security over sealed sources. State radiological protection agencies can provide valuable expertise on the licensees that they have been regulating, in many cases, for decades. Developing criteria and performance measures to gauge NRC's and agreement states' effectiveness at implementing additional security as part of NRC's performance evaluation process would help ensure the consistent application of additional security measures across the United States. NRC and the agreement states have a proven record of cooperation in regulating the safe use of radioactive materials, including sealed sources. As increasing demands are placed on budgets at all levels of government, effectively leveraging the knowledge and resources of federal, state, and local agencies will be crucial to ensuring that sealed sources continue to be used safely and remain secure against terrorist use.

Recommendations for Executive Action

To determine the sealed sources of greatest concern, we recommend that the Chairman of NRC collaborate with the agreement states to identify the types, amount, and availability of the highest risk sealed sources and the associated health and economic consequences of their malicious use. In addition, we recommend that NRC and the agreement states determine how to effectively mitigate the psychological effects of their use in a terrorist attack.

In addition, accountability over generally licensed devices needs to be improved and gaps in the current licensing process need to be addressed. Because new efforts will involve additional licensing and inspection of potentially thousands of licensees and devices, we recommend that the Chairman of NRC:

- determine, in consultation with the agreement states, the costs and benefits of requiring owners of devices that are now generally licensed

to apply for specific licenses and whether the costs are commensurate with the risks these devices present and

- modify NRC's process of issuing specific licenses to ensure that sealed sources cannot be purchased before NRC's verification—through inspection or other means—that the materials will be used as intended.

Finally, to ensure that the federal and state governments' efforts to provide additional security to sealed sources are adequately integrated and evaluated for their effectiveness, we recommend that the Chairman of NRC:

- determine how officials in agreement and non-agreement states can participate in the development and implementation of additional security measures and

- include criteria and performance measures of the NRC's and the agreement states' implementation of additional security measures in NRC's periodic evaluations of its and agreement states' effectiveness.

Agency Comments and Our Evaluation

We provided NRC, CRCPD, and OAS with draft copies of this report for their review and comment. NRC's written comments are presented as appendix VI. NRC, CRCPD, and OAS also provided technical comments, which we incorporated into the report as appropriate.

NRC stated that the draft report does not fully present either the current status of NRC's efforts to improve the security of high-risk radioactive sources or the large effort that it has devoted to this issue since September 11, 2001. According to NRC, the draft report does not fully reflect its existing statutory framework and does not recognize that several of our recommendations would require statutory changes at both federal and state levels. Furthermore, NRC commented that our draft report should have focused on high-risk radioactive sources that are of greatest concern for malevolent use by a terrorist rather than radioactive sources of all types.

Regarding NRC's comments that our draft report does not fully discuss its activities to increase the security of the highest-risk sealed sources, we note that our draft report detailed all advisories issued by NRC to sealed source licensees urging them to ensure security of sealed sources following September 11, 2001, as well as NRC's efforts with DOE to define the

radioactive isotopes of concern. We have added information on the organization and goals of NRC's new materials security working group. Furthermore, our report discusses that NRC's security order to large irradiators was issued on June 5, 2003. This order was issued four days after our meeting with NRC officials to discuss our preliminary findings, conclusions, and recommendations. At the meeting, NRC officials told us that it could take until the end of 2003 for the order to be issued. It is important to note that this is the first and only security order related to sealed sources issued since the September 11, 2001, attacks and that it applies only to 70 large irradiator facilities in the United States. As discussed in our draft report, 93 percent of agreement states responding to our survey identified industrial radiographers, of which there are over 500 nationwide, as of greater concern than large irradiator facilities.

Regarding NRC's comment that our draft report does not recognize that several of our recommendations would require statutory changes at both federal and state levels, we have clarified our report to recommend that NRC determine how officials in agreement and non-agreement states can participate in the development and implementation of additional security measures. We agree with NRC that its statutory framework reserves to NRC the authority to promote the common defense and security and our report discusses the distinction between federal and state authority. However, we continue to believe, as do state officials we spoke with, that involving the agreement and non-agreement states in the development and implementation of additional security measures would be beneficial. As our draft report stated, state and local governments will almost invariably be the first responders to any terrorist event involving sealed sources. States can also provide valuable expertise on licensees that they have been regulating for decades and which NRC has had no prior contact with. In its comments, NRC states that the possibility of state budget shortfalls played absolutely no role in its decision to develop and implement additional security measures under its common defense and security authority. However, numerous NRC officials told us during our review that budget difficulties could impact the performance of state radiation protection programs and NRC's former Chairman discussed the issue at a January 2003 meeting. NRC acknowledges in its comments that cooperation with agreement states is vital to the success of its efforts. We are encouraged that NRC stated in its comments that it will examine changes to its statutory framework in its new materials security working group and intends to work with the states to the maximum extent possible under existing statutes.

Regarding NRC's comment that the draft report should have focused only on high-risk sources rather than radioactive sources of all types, we note that the objectives of our review included determining the known number of all sealed sources in the United States and the number of sources lost, stolen, or abandoned. Our draft report noted that defining the types of sealed sources that are of the greatest concern would allow federal and state efforts to be appropriately prioritized. As we did when responding to a similar comment NRC made in our May 2003 report, we agree that the highest-risk sources present the greatest concern as desirable material for a dirty bomb.[27] However, other sealed radioactive sources could also be used as a terrorist weapon. No one can say with certainty what the psychological, social, or economic costs of a dirty bomb—regardless of the radioactive material used to construct it—would be. We are concerned that NRC's and DOE's identification of the highest-risk sealed sources focuses solely on the health risks of their use and does not address the psychological, social, or economic costs of a dirty bomb. It is also important to note that NRC is still working with the International Atomic Energy Agency to reconcile differences between their definitions of high-risk sealed sources. Furthermore, many of the radioactive isotopes identified by NRC and DOE as high-risk are used only at DOE facilities or by very few NRC licensees in the United States. NRC and DOE did not consider radioactive materials licensees in the agreement states, which constitute 80 percent of the nation's licensees. Without addressing the total consequences of a dirty bomb and considering the availability of sealed sources nationwide, we believe NRC's and DOE's determination of risk is incomplete.

In general, both CRCPD and OAS agreed with the recommendations in the report. However, both organizations noted that our use of the term "sealed source" to refer to all radioactive materials used in medical, industrial, and research purposes may exclude many radioactive isotopes that could be used in a dirty bomb that are loose and not in sealed form, especially those used in medical and research facilities. We used the term "sealed source" for simplicity to distinguish medical, industrial, and research radioactive isotopes from material used in nuclear weapons and as fuel in nuclear reactors. We did not intend to exclude unsealed radioactive material from

[27]See U.S. General Accounting Office, *Nuclear Nonproliferation: U.S. and International Assistance Efforts to Control Sealed Radioactive Sources Need Strengthening*, GAO-03-638 (Washington, D.C.: May 16, 2003).

our discussion of radioactive materials of concern and have clarified our use of the term.

CRCPD stated that the report does not address four critical areas of potential risk. First, CRCPD believes that a major area of risk is at bankrupt facilities where sealed sources can be left unattended and/or unsecured for long periods of time, leaving the sources easy targets for theft. We acknowledge this risk and have revised our discussion of lost, stolen, and abandoned sources appropriately. Second, CRCPD noted that radioactive materials licensed for "storage only" tend to be neglected by the licensee and the regulatory agency. While we agree that this is a potential weakness in sealed source security, individual state practices on "storage only" licenses differ. We did not specifically examine these practices during our review. Third, CRCPD stated that the report does not adequately address the radioactive material under the control of DOE and naturally occurring and accelerator produced radioactive material. While DOE does control a large amount of radioactive material, discussion of the security provided to it was outside of the scope of our review. We believe our report adequately discusses the challenges of regulating naturally occurring and accelerator produced materials. Finally, CRCPD states that the report does not consider transportation hubs through which very large quantities of radioactive material pass each day. While we do not specifically discuss transportation hubs, our draft report noted that weaknesses have been identified in the transportation of sealed sources and, at certain phases of transport, these shipments could be vulnerable to terrorist diversion.

OAS agreed with our recommendation that NRC should include criteria and performance measures of the agreement states' implementation of additional security measures in NRC's periodic evaluations of agreement states' effectiveness. OAS stated that such evaluation is not possible given the current intention of NRC to issue and implement security orders under its common defense and security authority. However, we believe that the recommendation in our draft report that NRC determine how states can participate in the development and implementation of additional security measures addresses this concern.

OAS also noted that our draft report stated that licensees are tracked instead of individual sealed sources and that the draft report lends support to the formation of a national tracking system for sealed sources. OAS commented that our discussion does not accurately describe the current system. Licensees are required to maintain records for the acquisition and disposition of each source it receives and maintain an accurate inventory of

sources in their possession. While we agree with this comment and have revised our discussion of license tracking, our draft report was accurate in that there is no single source of information in the United States to verify authorized users, locations, quantities, and movements of sealed sources. OAS goes on to state that there are serious concerns with the practicality and accuracy of a national tracking system and that the development of such a system should be further evaluated with input from the states and private industry. We agree with OAS's comments, but believe that our recommendation to collaborate with the agreement states in order to determine the types, amount, and availability of the highest risk sealed sources and the health, psychological, and economic consequences of their use in a terrorist attack addresses OAS's concerns.

Finally, OAS commented that the states have long requested that the federal government seriously consider placing the use and regulation of all radioactive materials in a single federal agency. According to OAS, the current approach results in a disjointed regulatory structure and different standards for the same public health issue. While we agree that consistency and avoiding duplication is important, addressing the overall regulation of radioactive material in the United States was outside the scope of our review on security of sealed sources.

We conducted our work from August 2002 through June 2003 in accordance with generally accepted government auditing standards. Appendix I presents our scope and methodology in detail.

As agreed with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution of it until 30 days from the date of this letter. We will then send copies to the Chairman and Commissioners of NRC; the Secretary of Homeland Security; the Secretary of Energy; the Administrator, National Nuclear Security Administration; the Director, Office of Management and Budget; the Chairman of the Organization of Agreement States; the Chairman and Executive Director of the Conference of Radiation Control Program Directors; the directors of the radiation control programs in the 32 agreement states; interested congressional committees; and other interested parties. We will also make copies available to others who request them. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions about this report, I can be reached at (202) 512-3841. Key contributors to this report are listed in appendix VII.

Sincerely yours,

Robert A. Robinson
Managing Director, Natural
Resources and Environment

Objectives, Scope, and Methodology

At the request of the Ranking Minority Member, Subcommittee on Financial Management, the Budget, and International Security, Committee on Governmental Affairs, U.S. Senate, we examined the following questions:

1. What is the known number of sealed sources in the United States?
2. How many of these sealed sources have been lost, stolen, or abandoned?
3. How effective are federal and state controls over sealed sources?
4. What efforts have been initiated or considered since September 11, 2001, to better safeguard radiological sources?

To answer these questions, we distributed surveys to 32 agreement states, 18 non-agreement states, Puerto Rico, the District of Columbia, and to NRC's 4 regional offices. We focused the survey on information about each state's radiation control program, specific and general licensing activities, enforcement actions, effectiveness of controls over sealed sources, program evaluation processes, transportation of sealed sources, and the impact of September 11, 2001, on regulatory programs. We acquired a list of the appropriate agreement and non-agreement state officials from NRC's Office of State and Tribal Programs Web site and from the Conference of Radiation Control Program Directors. Because this was not a sample survey, but rather a census of all states, there are no sampling errors. However, the practical difficulties of conducting any survey may introduce errors, commonly referred to as nonsampling errors. For example, measurement errors are introduced if difficulties exist in how a particular question is interpreted or in the sources of information available to respondents in answering a question. In addition, coding errors may occur if mistakes are entered into a database. We took extensive steps in the development of the questionnaires, the collection of data, and the editing and analysis of data to minimize total survey error. To reduce measurement error, we conducted two rounds of pretesting to make sure questions and response categories were interpreted in a consistent manner with both agreement and non-agreement states. We also provided draft copies of the questionnaires to NRC, the Organization of Agreement States (OAS), and the Conference of Radiation Control Program Directors (CRCPD) for their review and comment. Based on both pretesting and comments received from NRC, OAS, and CRCPD, we made relevant changes to the questions based upon these pretests. Copies of the agreement and non-agreement

state questionnaires, along with the results to each question, are in appendixes IV and V, respectively.

In addition, we edited all completed surveys for consistency and, if necessary, contacted respondents to clarify responses. All questionnaire responses were double key-entered into our database (that is, the entries were 100 percent verified), and a random sample of the questionnaires was further verified for completeness and accuracy. In addition, all computer syntax was peer reviewed and verified by separate programmers to ensure that the syntax was written and executed correctly.

We made extensive efforts to encourage respondents to complete and return the questionnaires, including sending up to four reminder electronic mail messages to non-respondents, calling state radiation control program directors directly, and collaborating with OAS to promote completion of this survey. Our efforts yielded responses from 31 of 32 (96.8 percent response rate) agreement states and 11 of 18 (61.1 percent response rate) non-agreement states. We also received responses from Puerto Rico and the four NRC regional offices. In total, we achieved an overall response rate of 80.4 percent, receiving 45 of the 56 surveys disseminated. We did not receive a response from one agreement state: Arizona. The non-agreement states of Alaska, Connecticut, Minnesota, Missouri, Pennsylvania, South Dakota, and Wyoming did not respond to our survey, nor did we receive a response from the District of Columbia. Although we did not receive surveys from these states, we obtained data on incidents involving sealed sources and numbers and types of licensees from NRC. Three states (New York, South Carolina, and Texas) have multiple agencies with jurisdiction over sealed sources. We sent and received surveys from the appropriate agencies in each of these states.

To determine the number and types of sealed source licenses in the United States and the number of sealed sources lost, stolen, or abandoned, we relied upon information provided by state radiation control programs in their responses to our survey. In addition, we obtained data from NRC's license tracking system database on licensees NRC regulates—both in the non-agreement states and on federal facilities in the agreement states. To determine the number of sealed sources lost, stolen, or abandoned over the past 5 years, we obtained data on incidents from NRC's Nuclear Materials Events Database. We chose to examine the past 5 years because information was readily available through this database. Because each state uses different systems to track its licensing activities, we did not attempt to independently assess the reliability of data provided by the

states in their responses to our survey. However, we did ask states in what ways and how frequently information in their databases is validated. To assess the reliability of NRC's databases, we interviewed officials at NRC in charge of maintaining its license tracking system database and the Nuclear Materials Events Database to determine if data in these systems are reasonably complete and accurate. As a result of these interviews, we did not find any reasons to question the reliability of these data. In addition, we also performed limited testing on NRC's license tracking system database to find missing data or data outside expected ranges. We did not find significant errors or incompleteness as a result of these tests and concluded that the use of the data would not lead to incorrect or unintentional findings. These are the only data on NRC licensing activities in the United States and program managers at NRC regularly use the data.

In addition to data on state programs obtained through our survey, we obtained information through interviews with officials from state radiation control programs. We visited the following states during our review: Florida, Georgia, Illinois, Maryland, New Jersey, North Carolina, Pennsylvania, Rhode Island, South Carolina, and Utah. We also interviewed officials from the Massachusetts, Nevada, New York, and Ohio state radiation control programs.

We selected states to visit based upon the numbers of licensees regulated by the state and the different uses of sealed sources. We selected states with a low number of licensees (Rhode Island, South Carolina, and Utah), a medium number of licensees (Georgia, Maryland, New Jersey, North Carolina, and Pennsylvania), and a high number of licensees (Florida and Illinois). In addition, we considered the types of licensees in each state. For example, we visited South Carolina and Utah because they have two of the nation's three low-level radioactive waste disposal facilities—the Chem-Nuclear Systems, L.L.C. facility in Barnwell, South Carolina and the Envirocare of Utah, Inc., facility in Clive, Utah. When visiting states, we met with officials from selected licensees that represented the major uses of sealed sources. We also visited manufacturers because they may possess larger quantities of radioactive material for installation in devices for sale. In summary, we visited three sites being decommissioned and decontaminated, two low-level radioactive waste disposal facilities, two moisture/density gauge manufacturers, two industrial radiographers, two medical licensees (hospitals), two large irradiator facilities, a well-logging licensee, a nuclear pharmacy, a research and development licensee, and an academic licensee to obtain their views on the effectiveness of NRC and state regulations, including the challenges associated with sealed source

security. Additionally, we examined physical security measures during tours of these facilities.

We also visited Rhode Island, Florida, and the NRC Region III office in Lisle, Illinois, because they were undergoing NRC program performance evaluation reviews under the Integrated Materials Performance Evaluation Program. Visiting a program while it was being evaluated gave us the opportunity to witness review procedures for evaluating performance, consistency of application of NRC's review criteria, transparency of the review process, and the level of cooperation and involvement between NRC officials and representatives from agreement states. To follow up our review of the program evaluation process, we attended a 2-day NRC training class on the Integrated Materials Performance Evaluation Program and observed two program evaluation Management Review Board meetings at NRC headquarters in Rockville, Maryland.

We attended two conferences related to sealed source regulation—the May 2002 CRCPD annual meeting held in Madison, Wisconsin, and the annual OAS Conference held in October 2002, in Denver, Colorado. We also obtained a position paper from the Health Physics Society on the regulation of sealed sources. Furthermore, we met with the chairman of the Southeast Compact for low-level radioactive waste and the Advisory Committee on the Medical Uses of Isotopes to elicit views on the regulation and security of sealed sources.

At the federal level, we interviewed numerous NRC officials representing several different offices and programs. During these interviews, NRC provided us with information and documents about the regulation of sealed sources and the challenges it faces in the post September 11, 2001, security environment. We met with NRC's Office of Enforcement, Office of Investigation, Office of Nuclear Materials Safety and Safeguards, Office of Nuclear Security and Incident Response, and Office of State and Tribal Programs. Additionally, we attended an August 2002 meeting between representatives of OAS and CRCPD and the Commissioners of NRC. Finally, to gain the perspective of federal regulators at the regional level, we visited three of the four NRC regional offices, including NRC Region I located in King of Prussia, Pennsylvania; Region II located in Atlanta, Georgia; and Region III located in Lisle, Illinois.

In addition to officials at NRC, we interviewed several other federal government agency officials. To learn about sealed source transportation regulations and issues, we interviewed officials from the Department of

Transportation, including the Office of Hazardous Materials Safety. To establish the role of the Environmental Protection Agency in regulating sealed sources, we met with officials from the Office of Radiation and Indoor Air. We also met with officials from the Federal Emergency Management Agency (FEMA) and observed a FEMA evaluated exercise in March 2003 in Springfield and Morris, Illinois, that simulated a radiological release at a nuclear power plant. We also interviewed Department of Justice and Department of Energy officials.

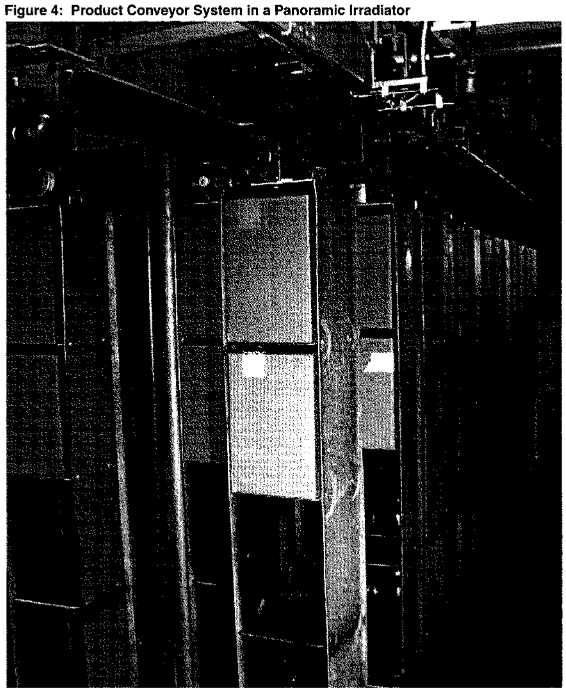
We performed our review from August 2002 through June 2003 in accordance with generally accepted government auditing standards.

Medical and Industrial Devices That Use Sealed Sources

Irradiators

Irradiators are devices or facilities that expose products to radiation for sterilization, such as spices, milk containers, and hospital supplies. Irradiator facilities are relatively few in number and contain very high activity sources, which vary in physical size. Non-self shielded irradiators do not provide shielding from the radiation beam; therefore, the facilities that contain the irradiation must be specially designed, often including thickly shielded walls, interlocks, and other protective equipment. Self-shielded irradiators do not emit external radiation beams and are usually small cabinet type devices. These irradiators are commonly used in research applications or for blood irradiation. According to our survey and NRC specific license data, there are a total of approximately 350 irradiator specific licensees in the United States, about 70 of which are large irradiators.

Figure 4: Product Conveyor System in a Panoramic Irradiator



Source: Ethicon, Inc. Used with permission.

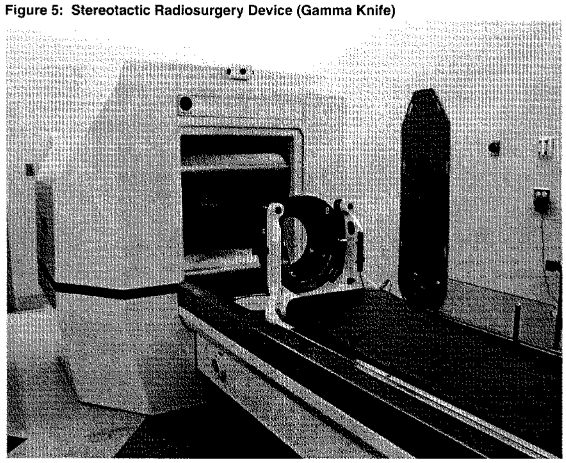
Note: Cobalt-60 sealed sources are placed in racks and stored while not in use in a deep water-filled pool beneath the product conveyor system.

Teletherapy

Teletherapy is commonly referred to as external beam radiation. Fixed multibeam teletheraphy units focus gamma radiation from an array of over

200 cobalt-60 sources on cancer lesions. The facilities within which the units are located are specifically designed to include thickly shielded walls and have other protective equipment, due to the high activity sources. According to our survey and NRC specific license data, there are approximately 60 teletherapy licensees and about 60 gamma knife licensees in the United States.

Figure 5: Stereotactic Radiosurgery Device (Gamma Knife)



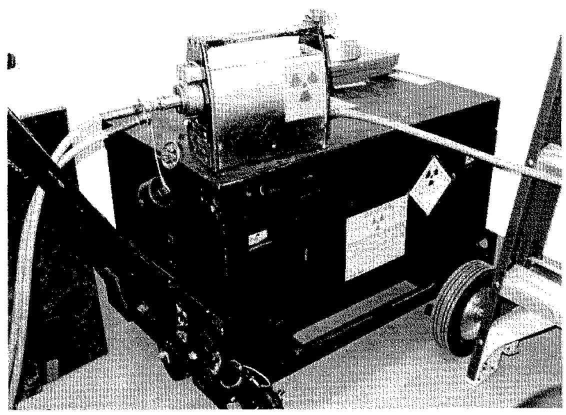
Source: GAO.

Industrial Radiography

Industrial radiography is the use of radiation to produce an image of internal features on photographic film to inspect metal parts and welds for defects. Industrial radiography sources and devices are generally small in terms of physical size, although the devices are usually heavy due to the internal shielding. The sources are attached to specially designed cables for their operation. The use of radiography sources and devices is very common—a total of over 570 licensees nationwide—and their portability

may make them susceptible to theft or loss. Further, the small size of the source allows for unauthorized removal by an individual, and such a source may be placed into a pocket of a garment. Industrial radiography cameras typically contain a high radioactivity iridium-192 source that is capable of inflicting extensive radiation burns if handled improperly.

Figure 6: Industrial Radiography Camera and Storage Case



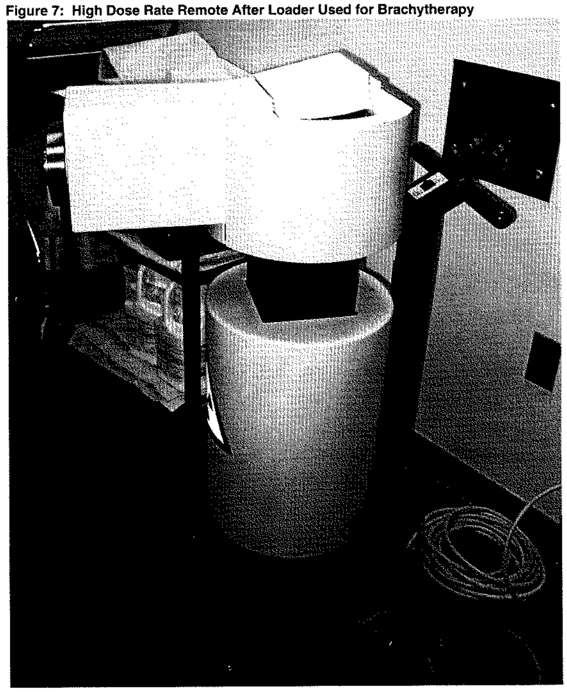
Source: GAO.

Brachytheraphy

Brachytherapy is an advanced cancer treatment in which radioactive seeds or sources are placed in or near the tumor itself, giving a high radiation dose to the tumor while reducing the radiation exposure in the surrounding healthy tissues. Brachytheraphy applications are of three slightly different varieties, generally referred to as low dose rate, medium dose rate, and high dose rate. These applications use sealed sources that are small physically (less than 1 centimeter in diameter and only a few centimeters long), and, thus, are susceptible to being lost or misplaced. High and medium dose rate sources, and some low dose rate sources, may be in the

form of a long wire attached to a device (a remote after loading device). The after loading device may be heavy, due to the shielding for the sources when not in use, and the device may be on wheels for transport within a facility. The remote after loading device may also contain electrical and electronic components for its operation. Brachytherapy sources and devices are located in hospitals, clinics, and similar medical institutions, and such facilities may have a large number of sources.

Figure 7: High Dose Rate Remote After Loader Used for Brachytherapy



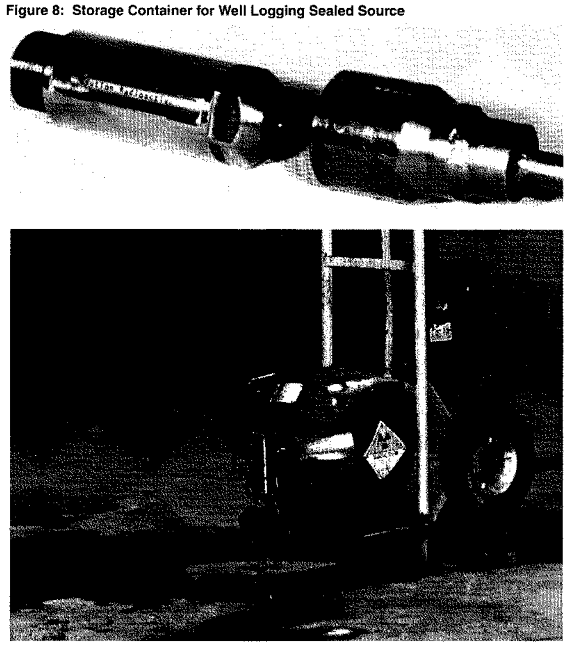
Source: GAO.

Well Logging Device

Well logging is a process that uses sealed sources and/or unsealed radioactive materials to determine whether a well, drilled deep into the ground, contains minerals, such as coal, oil, and natural gas. The sources

are usually contained in long (1 to 2 meters, typically) and thin (less than 10 centimeters in diameter) devices that also contain detectors and various electronic components. The actual size of the sources inside the devices is generally small, but the device is heavy, due to the ruggedness needed for the environments in which they are to be used. Our analysis of NRC's license tracking system and responses to our survey of agreement states indicates that there are about 210 well logging licensees in the United States.

Figure 8: Storage Container for Well Logging Sealed Source



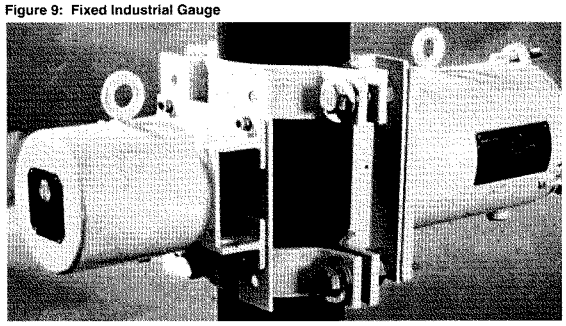
Sources: NRC (top), GAO (bottom).

Fixed Industrial Gauge

Non-portable gauging devices are designed for measurement or control of material density, flow, level, thickness, weight, and so forth. The gauges—possessed by over 1,600 specific licensees and an unknown number of general licensees—contain sealed sources that radiate through the substance being measured to a readout or controlling device. Depending

upon the specific application, industrial gauges may contain relatively small quantities of radioactive material, or may contain sources with activities approaching 30 curies. The devices generally are not large, but may be located some distance from the radiation detector, which may have electrical or electronic components located within the detector. A facility may have a large number of these gauges and the locations of such devices or sources within a facility may not be recognized, since the devices may be connected to process control equipment. This lack of recognition may result in a loss of control if the facility decides to modernize or terminate operations.

Figure 9: Fixed Industrial Gauge

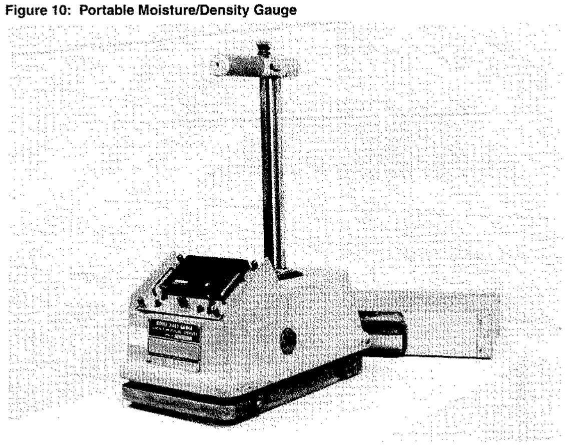


Source: NRC.

Portable Gauge

Portable gauging devices, such as moisture density gauges, are used at field locations and contain the sources, detectors, and electronic equipment necessary for the measurement. These gauges—over 4,600 licensees in the United States—contain a gamma emitting sealed source, usually cesium-137, and a sealed neutron source, usually americium-241 and beryllium. The source is physically small in size, typically a few centimeters long by a few centimeters in diameter, and may be located either completely within the device or at the end of a rod/handle assembly. The portability of the device makes it susceptible to loss of control or theft.

Figure 10: Portable Moisture/Density Gauge



Source: GAO.

Table 2: Type and Size of Sealed Sources Used in Medical and Industrial Practices

Practice or Application	Use	Radioisotope	Range of radioactivity level (curies)
Irradiator (sterilization/food preservation)	Industrial	Cobalt-60	5,000-15,000,000
		Cesium-137	5,000-5,000,000
Irradiator (self-shielded)	Research	Cesium-137	2,500-42,000
		Cobalt-60	1,500-50,000
Irradiator (blood)	Medical	Cesium-137	1,000-12,000
		Cobalt-60	1,500-3,000
Teletherapy	Medical	Cobalt-60	1,000-15,000
		Cesium-137	500-1,500
Teletherapy (fixed, multibeam/gamma knife)	Medical	Cobalt-60	4,000-10,000
Industrial radiography	Industrial	Cobalt-60	11-200
		Iridium-192	5-200
		Selenium-75	80
		Ytterbium-169	2.5-10
		Thulium-170	20-200
Brachytherapy (high/medium dose rate)	Medical	Cobalt-60	5-20
		Cesium-137	3-8
		Iridium-192	3-12
Brachytherapy (low dose rate)	Medical	Cesium-137	.01-.7
		Radium-226	.005-.05
		Strontium-90	.02-.04
		Palladium-103	.03
		Iodine-125	.04
		Iridium-192	.02-.75
		Gold-198	.08
		Californium-252	.083
		Ruthenium/Rhodium-106	.00022-.0006
Well logging gauge	Industrial	Americium-241/Beryllium	.5-23
		Cesium-137	1-2
		Californium-252	.027-.11
Fixed industrial gauge (e.g. level/thickness gauge)	Industrial	Americium-241	.012-.12
		Cesium-137	.05-.065
Portable gauge (e.g. moisture/density gauge)	Industrial	Americium-241/Beryllium	.01-.1

(Continued From Previous Page)

Practice or Application	Use	Radioisotope	Range of radioactivity level (curies)
		Cesium-137	.008-.011
		Radium-226	.002-.004
		Californium-252	.00003-.00007

Source: International Atomic Energy Agency, "Categorization of Radioactive Sources, Revision of IAEA-TECDOC-1191" Vienna, Austria, 2003.

Appendix III

Legislation Introduced in the 108th Congress Addressing Security of Sealed Sources

Legislation	Major Efforts	Study Requested
S.6 Comprehensive Homeland Security Act of 2003 Sec. 3006 and Sec. 170.	Amends the Atomic Energy Act of 1954 to include the following major efforts: (1) based on a new classification system, develop a national system for recovery of sealed sources that are stolen or lost; (2) develop a national tracking system that takes into account the new classification system; and (3) establish procedures to improve the security of sealed sources in use, transport, and storage.	Establishes a task force to develop a classification system for sensitive sealed sources that is based on the potential for use by terrorists and the extent of the threat to public health and safety.
S.350 A bill to amend the Atomic Energy Act of 1954 to strengthen the security of sensitive radioactive material.	Directs a task force to (1) determine which sealed sources should be classified as sensitive sealed sources, (2) develop a national system to recover sensitive sealed sources that are lost or stolen, (3) develop a national tracking system for sealed sources, and (4) establish procedures to improve the security of sensitive sealed sources.	Establishes a multiagency task force to evaluate the security of sealed sources and recommends administrative and legislative actions to provide the maximum degree of security against radiological threats.
H.R.891 A bill to establish a task force to evaluate and make recommendations with respect to the security of sealed sources of radioactive materials, and for other purposes.	Directs a task force to (1) establish or modify a classification system for sealed sources based on sealed source attractiveness to terrorists, (2) establish or modify a national tracking system, (3) establish a system to impose refundable fees for proper disposal, and (4) improve the security of sealed sources.	Establishes a multiagency task force to, in consultation with state agencies, make recommendations for appropriate regulatory and legislative changes to strengthen controls over sealed sources.
S. 1043 A bill to provide for the security of commercial nuclear power plants and facilities designated by the Nuclear Regulatory Commission Sec. 6	Changes the definition of byproduct material to include naturally occurring and accelerator produced radioactive material and, within 4 years, transition regulatory authority over this material from non-agreement states to the Nuclear Regulatory Commission.	None.
S. 1005 The Energy Policy Policy Act of 2003 Title IX Subtitle D—Nuclear Energy Sec. 946	Instructs the Secretary of Energy to establish a research and development program to develop alternatives to sealed sources that reduce safety, environmental, or proliferation risks to workers using the sources or the public.	Directs the Secretary of Energy to conduct a survey of industrial applications of large radioactive sources. Requires the survey to include information on the management and disposal of sealed sources.
S. 1045 Low-Level Radioactive Waste Act of 2003	Directs the Secretary of Energy to (1) identify options for disposal of low-level radioactive waste, (2) develop a report for Congress on a permanent disposal facility for greater-than-Class C waste, and (3) submit to Congress a plan to ensure continued recovery of greater-than-Class C waste until a permanent disposal facility is available.	None.

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Legislation	Major Efforts	Study Requested
S. 1161 Foreign Assistance Authorization Act, fiscal year 2004 Title III Sec. 301—308 Radiological Terrorism Threat Reduction Act of 2003	Authorizes the Secretary of Energy to engage in activities with the International Atomic Energy Agency to (1) propose and conclude agreements with up to 8 countries under which the countries would provide temporary secure storage for orphaned, unused, and surplus sealed sources, (2) promote the discovery, inventory, and recovery of sealed sources in member nations, and (3) authorizes the Secretary of Energy to make voluntary contributions to the International Atomic Energy Agency to achieve the aforementioned goals.	None.

Source: GAO.

Appendix IV

Results of Survey of Agreement States

United States General Accounting Office

GAO Accountability • Integrity • Reliability

Agreement State Survey on Security of Radioactive Sources

Background

The U.S. General Accounting Office (GAO), the investigative arm of Congress, is reviewing the regulation of radioactive materials in the United States. Congress has asked the GAO to answer the following questions:

1. What is the known universe of radiological sources in the United States and how many have been lost, stolen, or abandoned?
2. How effective are federal and state controls over radiological sources?
3. What efforts are underway since September 11, 2001, to improve the controls over radiological sources?

As part of our review, we are conducting surveys of state radiation control agencies, including agreement and non-agreement states, Puerto Rico, Guam, and the District of Columbia. The principal aims of this survey are to obtain information from each state on the number and types of radiological sources being regulated by the state and obtain states' views on the effectiveness of the current federal and state regulatory framework.

Your cooperation in completing this survey is essential for an accurate and timely report to the Congress on the current state of regulatory control over radioactive materials. To be included in our report, your response within 3 weeks of receipt is greatly appreciated.

Directions for Completing this Questionnaire

Please complete this questionnaire and return it via email (**ColesR@gao.gov**), fax **(202-512-6880)**, or FedEx within 3 weeks of receipt. GAO will take steps to safeguard the privacy of your responses.

If you have any questions about the survey, please contact:

Ryan T. Coles
Office: 202-512-6888
E-mail: ColesR@gao.gov

Peter Ruedel
Office: 202-512-8753
E-mail: RuedelP@gao.gov

Heather Von Behren
Office: 202-512-6768
E-mail: VonBehrenH@gao.gov

If you prefer to return the survey via FedEx, the return address is:

U.S. General Accounting Office
Attention: Ryan T. Coles
Natural Resources and Environment
441 G Street, NW Room 2T23
Washington, DC 20548

Due to increased security put in place following the anthrax incidents of October 2001, please do not use the U.S. Postal Service to return surveys to GAO.

Although this questionnaire may require input from various individuals, we ask that one person assume responsibility for coordinating its completion. Please list that person's name below in case we have questions or need follow-up. Thank you.

Name:

Title:

Telephone #:

E-mail:

1

PROGRAM INFORMATION

1. **First, we'd like to get some basic information about your state's radiation control program. Please provide the following information.**

   Program name:

   State department/division/office (e.g. Department of Health):

   City the main office is located in:

   State:

   Current director of program:

2. **Please list your program's total budget for the following calendar years:**

2000 (Actual)	**$51,463,128 (N=30)**
2001 (Actual)	**$56,975,299 (N=31)**
2002 (Actual)	**$59,712,939 (N=32)**
2003 (Projected)	**$61,039,121 (N=31)**

3. **What are the sources of your program's funding? (*Mark all that apply* ☒) (N=35)**

   94.3% Fees charged to licensees
   45.7% Appropriations from state general fund
   60.0% Other, please specify:

4. **How many full-time equivalent (FTE) staff does your program currently employ? (N=35)**

   754

2

5. **Of the total number of staff reported in question #3, how many FTEs do you have in the following categories?**

Category of Staff	Number
Inspectors	
License reviewers	
Other Technical Staff	
Other Non-Technical Staff	

6. **How many of your technical staff (including inspectors and license reviewers) are professionally certified (e.g. certified health physicists, nuclear medicine technologists, etc.)?**

7. **How many staff were employed in your state in the following categories on January 1, 1998? (N=34)**

Category of Staff	Number on January 1, 1998
Inspectors	
License reviewers	
Other Technical Staff	
Other Non-Technical Staff	
TOTAL	750

8. **Over the next five years, do you estimate your total full-time equivalent positions will increase or decrease for technical and non-technical staff?** ***(Mark only one response ☒ for each type of staff)*** **(N=34)**

Technical Staff		Non-Technical Staff	
17.7%	Increase	17.7%	Increase
11.8%	Decrease	11.8%	Decrease
70.6%	Stay about the same	70.6%	Stay about the same

9. **In what year did your agreement with the NRC, or its predecessor, the Atomic Energy Commission, first enter into force?**

1	9		

3

SPECIFIC LICENSING ACTIVITIES OF THE AGREEMENT STATES

10. Please complete the following table on the total number of active specific licenses for Atomic Energy Act materials issued by your state as of December 31, 2002:

10 CFR part(s) or the applicable agreement state equivalent	Active licenses as of December 31, 2002
Part 32	**380 (N=29)**
Part 33	**248 (N=29)**
Part 34	**417 (N=29)**
Part 35	**4,795 (N=29)**
Part 36	**134 (N=29)**
Part 39	**167 (N=29)**
Part 40	**137 (N=28)**
Part 70	**95 (N=27)**
Total	**10,611 (N=32)**
Naturally occurring radioactive materials	**153 (N=20)**
Accelerator produced radioactive materials	**324 (N=19)**

11. Next, we'd like to obtain data on the number of active specific licenses issued by your state program as of December 31, 2002 and how often licensees are inspected. ***Enter number and mark only one response ☒ in each row for most common inspection frequency within that particular code. If none, please enter "0" (zero).*** (N=35)

29 — **Please check this box if the license information below includes non-Atomic Energy Act materials (i.e. naturally occurring or accelerator produced radioactive materials)**

NRC license tracking system program code and license use		Number of licensees	Most Common Inspection Frequency Within This Code
03250	Introduction of byproduct material in exempt concentrations into products or materials, and transfer of ownership or possession	**8 (N=33)**	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required

4

NRC license tracking system program code and license use		Number of licensees	Most Common Inspection Frequency Within This Code
03251	Application of byproduct material into devices exempt from regulation under §30.15	0 (N=33)	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
03252	Manufacture of resins containing scandium-46 designed for sand-consolidation in oil wells	2 (N=33)	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
03253	Manufacture, distribution, and transfer of exempt quantities of byproduct material	15 (N=32)	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
03256	Manufacture, preparation, or transfer of capsules containing carbon-14 urea for "in vivo" diagnostic use in humans	14 (N=33)	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required

NRC license tracking system program code and license use		Number of licensees	Most Common Inspection Frequency Within This Code
03254	Manufacture, process, produce, or initially transfer self-luminous products containing tritium, krypton-85 or promethium-147	6 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03255	Manufacture, process, produce, or initially transfer gas and aerosol detectors containing byproduct material	1 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03240	Manufacture or initially transfer generally licensed devices under §31.5	74 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03241	Manufacture, assemble, repair, or initially transfer luminous safety devices for use in aircraft	1 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required

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NRC license tracking system program code and license use		Number of licensees	Most Common Inspection Frequency Within This Code
03242	Manufacture or initially transfer calibration or reference sources containing americium-241	5 (N=32)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03243	Manufacture or initially transfer ice detection devices containing strontium-90	1 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03244	Manufacture and distribution of byproduct material for in-vitro clinical or laboratory testing under general license	25 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
02511	Manufacture, preparation, or transfer for commercial distribution of radioactive drugs containing byproduct material for medical use under part 35.	62 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required

NRC license tracking system program code and license use		Number of licensees	Most Common Inspection Frequency Within This Code
02513	Manufacture and distribution of sources or devices containing byproduct material for medical use	20 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
01100	Academic type A specific license of broad scope	100 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03211	Manufacturing and distribution type A specific license of broad scope	11 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03610	Research and development type A specific license of broad scope	57 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required

8

NRC license tracking system program code and license use		Number of licensees	Most Common Inspection Frequency Within This Code
01110	Academic type B specific license of broad scope	21 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03211	Manufacturing and distribution type B specific license of broad scope	8 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03611	Research and development type B specific license of broad scope	7 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
01120	Academic type C specific license of broad scope	31 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required

9

NRC license tracking system program code and license use		Number of licensees	Most Common Inspection Frequency Within This Code
03213	Manufacturing and distribution type C specific license of broad scope	1 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03612	Research and development type C specific license of broad scope	14 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03310	Industrial radiography fixed location	95 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03320	Industrial radiography temporary job sites	379 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required

NRC license tracking system program code and license use	Number of licensees	Most Common Inspection Frequency Within This Code
02120 02121 Medical institution	2,519 (N=32)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
02200 02201 Medical private practice	1,805 (N=32)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
02220 02231 02240 Mobile medical service	187 (N=32)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
02210 Eye applicators (strontium-90)	74 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required

NRC license tracking system program code and license use	Number of licensees		Most Common Inspection Frequency Within This Code
02300 Teletherapy	55 (N=33)	☐ ☐ ☐ ☐ ☐ ☐	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
02310 Stereotactic radiosurgery—gamma knife	45 (N=33)	☐ ☐ ☐ ☐ ☐ ☐	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
02400 Veterinary non-human	110 (N=33)	☐ ☐ ☐ ☐ ☐ ☐	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
02410 In-vitro testing laboratories	147 (N=33)	☐ ☐ ☐ ☐ ☐ ☐	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required

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NRC license tracking system program code and license use	Number of licensees	Most Common Inspection Frequency Within This Code
02500 Nuclear pharmacies	280 (N=33)	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
03510 Irradiators self shielded less than 10,000 curies	176 (N=33)	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
03511 Irradiators other less than 10,000 curies	17 (N=33)	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
03520 Irradiators self shielded greater than 10,000 curies	9 (N=33)	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required

NRC license tracking system program code and license use		Number of licensees	Most Common Inspection Frequency Within This Code
03521	All other irradiators greater than 10,000 curies	**40 (N=33)**	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
03110	Well logging byproduct and/or special nuclear material tracer and sealed sources	**70 (N=33)**	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
03111	Well logging byproduct and/or special nuclear material sealed sources only	**40 (N=33)**	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
03112	Well logging byproduct only	**64 (N=33)**	☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required

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NRC license tracking system program code and license use	Number of licensees	Most Common Inspection Frequency Within This Code
03120 Fixed gauges	1,193 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03121 Portable gauges	3,715 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03122 Analytical instruments	369 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03123 Gas chromatographs	212 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03124 Other measuring systems	146 (N=33)	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required

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NRC license tracking system program code and license use		Number of licensees	Most Common Inspection Frequency Within This Code
03221	Instrument calibration service only—source less than 100 curies	**104 (N=33)**	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required
03222	Instrument calibration service only—source greater than 100 curies	**21 (N=33)**	More than once per year Once a Year Every 2-3 Years Every 4-5 Years Over 5 Years Inspection Not Required

12. **Please complete the following table for radioactive materials licenses issued by your state program that are NOT LISTED IN YOUR RESPONSE TO QUESTION 11.** ***Enter the license use, number of active licenses issued by your program, and mark only one response ☒ in each row for most common inspection frequency within that particular use.***

License use	Number of licensees	Most Common Inspection Frequency Within This Code
		☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
		☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
		☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
		☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required

License use	Number of licensees	Most Common Inspection Frequency Within This Code
		☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
		☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
		☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required
		☐ More than once per year ☐ Once a Year ☐ Every 2-3 Years ☐ Every 4-5 Years ☐ Over 5 Years ☐ Inspection Not Required

Please copy and paste above table for additional uses.

13. In your opinion, which 3 uses of radioactive materials, from the license uses listed in questions 11 and 12, require the strictest and least strict regulation to protect *public health and safety*?

Strictest regulation	Least strict regulation
1.	1.
2.	2.
3.	3.

14. In your opinion, which 3 uses of radioactive materials, from the license uses listed in questions 11 and 12, require the strictest and least strict regulation to ensure *security*? (i.e. to prevent the materials' use by terrorists in a radiological weapon)

Strictest regulation	Least strict regulation
1.	1.
2.	2.
3.	3.

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General License Tracking

15. Does your state program require generally licensed devices to be registered? *Mark only one response* ☒) (N=31)

80.6%	Yes, all generally licensed devices are required to be registered. (*skip to question 17*)
16.1%	Yes, but only certain generally licensed devices are required to be registered.
3.2%	No, generally licensed devices are not required to be registered with the state. (*skip to question 19*)

16. If only certain generally licensed devices are required to be registered, what criteria determine the devices required to be registered with the state program?

17. If generally licensed devices are required to be registered with your state program, does the program maintain a database of registered generally licensed devices? *Mark only one response* ☒)

☐ Yes
☐ No *(skip to question 19)*

18. If yes, how many generally licensed devices are currently registered in your state?

19. If your state program does not require any generally licensed devices to be registered or your state program does not maintain a database of registered generally licensed devices, how many such devices would you estimate are present in your state?

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SPECIFIC AND GENERAL LICENSE TRACKING OVERSIGHT

20. Briefly describe how your program maintains data on materials licenses and inspections.

21. Please estimate the percentage of inspections of your licensees that are currently overdue.

22. Are your databases (i.e. licensing records, computer files containing licensee information) periodically validated to ensure that licensees are still active (i.e. still conducting business)? *Mark only one response* ☒) (N=35)

97.1%	Yes
2.9%	No *(skip to question 25)*

23. How often do you validate your databases? *Mark only one response* ☒) (N=32)

46.9%	More than once per year
40.6%	Once a year
9.4%	Every 2-3 years
3.1%	Every 4-5 years
0.0%	Over 5 years

24. What steps are taken to validate information in your databases?

25. Does your state have a program to identify and recover abandoned sources? *Mark only one response* ☒) (N=35)

94.3%	Yes
5.7%	No *(skip to question 27)*

26. Briefly describe your state's program to identify and recover abandoned sources.

ENFORCEMENT ACTIONS

27. What enforcement actions are available to your state's program to ensure laws and regulations are followed? *(Mark all that apply ☒)* (N=35)

- [0.0%] No enforcement actions available ***(skip to question 31)***
- [100%] Notices of violation/citations
- [77.1%] Fines/civil penalties
- [88.6%] License suspension
- [97.1%] License termination
- [57.1%] Facility closure
- [71.4%] Imprisonment/criminal penalties
- [45.7%] Other, please specify:

28. Please complete the following table on your state program's enforcement activities over the past five years. If none, please enter "0" (zero):

	Number of enforcement actions per year				
Enforcement action	**1998**	**1999**	**2000**	**2001**	**2002**
Notices of violation only (without other action)	2,135 (N=24)	2,675 (N=25)	3,056 (N=27)	2,845 (N=28)	2,568 (N=28)
Fines/civil penalties	45 (N=23)	50 (N=24)	47 (N=24)	66 (N=26)	57 (N=25)
License suspension	3 (N=25)	3 (N=26)	8 (N=26)	9 (N=27)	9 (N=27)
License termination	24 (N=25)	25 (N=26)	26 (N=26)	27 (N=27)	53 (N=27)
Facility closure	1 (N=24)	0 (N=25)	1 (N=25)	0 (N=25)	1 (N=25)
Imprisonment/criminal penalties	0 (N=24)	0 (N=25)	2 (N=25)	0 (N=26)	2 (N=26)
Other:	7 (N=15)	6 (N=16)	14 (N=16)	56 (N=19)	87 (N=19)

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29. How are fines/civil penalties collected by your program utilized? (N=35)

25.7%	Available for use by the state radiation control program
45.7%	Deposited into state general fund
11.4%	Other, please specify:
20.0%	Not applicable

30. Please briefly describe any enforcement cases since January 1, 1998, that have been difficult to resolve, have generated above average public or press interest, have challenged your regulatory authority, or have or will result in high clean up costs financed by state or federal funds.

EFFECTIVENESS OF CONTROLS OVER RADIOACTIVE MATERIALS

31. To what extent, if at all, do you agree that communications and coordination needs to be improved between your state program and the following group? (***Mark only one response ☒ in each row***)

Group	Very great extent	Great extent	Moderate extent	Some Extent	Little or no extent	No Basis to Judge
a) the U.S. Nuclear Regulatory Commission (NRC) (N=35)	8.6%	2.9%	28.6%	28.6%	31.4%	0.0%
b) the U.S. Department of Energy (DOE) (N=35)	11.4%	20.0%	25.7%	22.9%	5.7%	14.3%
c) the Environmental Protection Agency (EPA) (N=35)	11.4%	14.3%	25.7%	28.6%	17.1%	2.90%
d) the Food and Drug Administration (FDA) (N=35)	2.9%	5.7%	20.0%	25.7%	35.7%	8.6%
e) the U.S. Department of Justice (DOJ) (N=35)	8.6%	14.3%	14.3%	8.6%	8.6%	45.7%
f) the U.S. Department of Transportation (DOT) (N=35)	5.7%	14.3%	28.6%	28.6%	14.3%	8.6%
g) other agreement states (N=35)	2.9%	0.0%	8.6%	20.0%	68.6%	0.0%
h) non-agreement states (N=35)	2.9%	0.0%	11.4%	25.7%	57.1%	2.9%
i) Organization of Agreement States (OAS) (N=34)	0.0%	2.9%	5.9%	23.5%	67.6%	0.0%
j) Conference of Radiation Control Program Directors (CRCPD) (N=34)	0.0%	2.9%	5.9%	17.6%	73.5%	0.0%

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32. To what extent, if at all, do you agree with the following statements? (*Mark only one response ☒ in each row*) (N=35)

Group	Very great extent	Great extent	Moderate extent	Some Extent	Little or no extent	No Basis to Judge
a) Communications and coordination needs to be improved between federal agencies with regulatory authority for radioactive materials	34.3%	34.3%	17.1%	14.3%	0.0%	0.0%
b) The current division of regulatory authority for radioactive materials between NRC, DOE, EPA, DOT and FDA is the most effective means of federal regulation	0.0%	2.9%	5.7%	20.0%	71.4%	0.0%
c) Consistent radiation protection standards need to be developed that would apply across all federal and state regulatory programs.	48.6%	31.4%	5.7%	8.6%	5.7%	0.0%
d) My state program *currently* has sufficient budgetary resources to effectively regulate radiological sources	8.6%	20.0%	25.7%	28.6%	17.1%	0.0%
e) My state program *currently* has sufficient technology (e.g. radiation survey meters, laboratory resources) to effectively regulate radiological sources	11.4%	31.4%	34.3%	17.1%	5.7%	0.0%
f) My state program *currently* has ***sufficient*** personnel to effectively regulate radiological sources	8.6%	31.4%	25.7%	25.7%	8.6%	0.0%
g) My state program *currently* has ***qualified*** personnel to effectively regulate radiological sources	22.9%	42.9%	17.1%	11.4%	5.7%	0.0%
h) NRC's Nuclear Materials Events Database (NMED) accurately and completely reflects incidents involving radioactive materials in my state	14.3%	25.7%	34.3%	17.1%	5.7%	2.9%

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Group	Very great extent	Great extent	Moderate extent	Some Extent	Little or no extent	No Basis to Judge
i) DOT's regulations adequately ensure safe and secure transport of radioactive materials	0.0%	40.0%	48.6%	8.6%	2.9%	0.0%
j) The federal government should have a greater role in regulating radioactive material in the United States	0.0%	0.0%	2.9%	40.0%	57.1%	0.0%
k) Additional federal training could improve regulation of radioactive material in my state	31.4%	28.6%	20.0%	11.4%	8.6%	0.0%
l) My state's public safety/law enforcement agencies need additional training to respond to radiological incidents	22.9%	31.4%	28.6%	8.6%	5.7%	2.9%
m) My state program can effectively respond to a radiological incident with its current resources	5.7%	22.9%	45.7%	20.0%	5.7%	0.0%
n) In the event of a major radiological incident, adequate federal resources can be brought to bear in a timely manner	5.7%	34.3%	20.0%	20.0%	5.7%	14.3%
o) My state program is adequately addressing the post-September 11th heightened security concerns involving malicious use of radioactive material (i.e. possible use as a "dirty bomb")	11.4%	42.9%	31.4%	11.4%	2.9%	0.0%
p) *Over the next five years*, my state program will have sufficient budgetary resources to effectively regulate radiological sources	8.6%	20.0%	25.7%	20.0%	17.1%	8.6%
q) *Over the next five years*, my state program will have sufficient technology (e.g. radiation survey meters, laboratory resources) to effectively regulate radiological sources	8.6%	25.7%	31.4%	22.9%	5.7%	5.7%

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Group	Very great extent	Great extent	Moderate extent	Some Extent	Little or no extent	No Basis to Judge
r) *Over the next five years*, my state program will have ***sufficient*** personnel to effectively regulate radiological sources	8.6%	20.0%	34.3%	20.0%	11.4%	5.7%
s) *Over the next five years*, my state program will have ***qualified*** personnel to effectively regulate radiological sources	8.6%	31.4%	22.9%	25.7%	5.7%	5.7%

33. Please fill in the following table on the number of reportable incidents (under NRC or equivalent agreement state regulations) involving radiological materials that have occurred in your state from 1998 through 2002. If no incidents, please enter "0" (zero).

Type of incident	Number of incidents per year				
	1998	1999	2000	2001	2002
Equipment malfunction	48 (N=24)	32 (N=26)	26 (N=25)	33 (N=25)	47 (N=26)
Radiation overexposure	18 (N=26)	33 (N=26)	33 (N=28)	32 (N=28)	21 (N=28)
Lost, stolen, or abandoned materials	100 (N=28)	129 (N=27)	129 (N=27)	167 (N=28)	220 (N=28)
Medical events	101 (N=24)	107 (N=24)	123 (N=27)	114 (N=27)	91 (N=26)
Transportation events	30 (N=26)	37 (N=26)	47 (N=28)	38 (N=28)	34 (N=27)
Leaking sealed sources	9 (N=25)	20 (N=27)	19 (N=27)	14 (N=27)	23 (N=28)
TOTAL	341 (N=29)	388 (N=29)	408 (N=30)	454 (N=30)	540 (N=30)

34. For those materials that have been reported lost, stolen, or abandoned from 1998 through 2002, how many were subsequently recovered? (N=22)

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INTEGRATED MATERIALS PERFORMANCE EVALUATION PROGRAM

35. Do you conduct periodic internal evaluations of your program's effectiveness? (*Mark only one response* ☒) (N=35)

100%	Yes
0.0%	No

36. Apart from the Integrated Materials Performance Evaluation Program, does an outside party regularly evaluate your program? (*Mark only one response* ☒) (N=35)

91.4%	Yes
8.6%	No

37. In your opinion, how adequate or inadequate are the following Integrated Materials Performance Evaluation Program performance indicators in evaluating your state's radiological protection programs? (*Mark only one response* ☒ *in each row*)

Performance Indicator	Very adequate	Generally adequate	Generally inadequate	Very inadequate	Not applicable
a) Status of evaluation program (N=35)	42.9%	48.6%	2.9%	0.0%	5.7%
b) Technical quality of inspections (N=35)	57.1%	37.1%	5.7%	0.0%	0.0%
c) Quality of technical staffing and training (N=35)	48.6%	40.0%	8.6%	2.9%	0.0%
d) Technical quality of licensing actions (N=35)	48.6%	48.6%	2.9%	0.0%	0.0%
e) Quality of response to incidents and allegations (N=35)	40.0%	51.4%	8.6%	0.0%	0.0%
f) Sealed source and device evaluation program (N=34)	8.8%	44.1%	5.9%	0.0%	41.2%
g) Low-level radioactive waste disposal program (N=34)	5.9%	17.6%	8.8%	0.0%	67.6%
h) Legislation and program elements required for compatibility (N=35)	42.9%	40.0%	14.3%	0.0%	2.9%

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38. What are the strengths of the Integrated Materials Performance Evaluation Program?

39. What are the weaknesses of the Integrated Materials Performance Evaluation Program?

40. Briefly, what improvements, if any, should be made to the Integrated Materials Performance Evaluation Program process?

41. Overall, is the Integrated Materials Performance Evaluation Program process an adequate means to assess the effectiveness of your state's regulatory program? (*Mark only one response* ☒) (N=35)

100%	Yes
0.0%	No

TRANSPORTATION OF RADIOACTIVE MATERIALS

42. Does your program regulate the transportation of radioactive material through your state? (N=35)

- 97.1% Yes
- 2.9% No

43. Do you require licensees to notify your program of shipments of radioactive material? (N=35)

- 97.1% Yes
- 2.9% No *(skip to question 46)*

44. If yes, which types of cargo do you require that your program be notified of shipments of?

45. Which of the following types of shipments does your state monitor? (N=35)

- 60.0% Spent nuclear fuel
- 57.1% DOE waste material (i.e. shipments to the Waste Isolation Pilot Plant)
- 51.4% Byproduct material with high radioactivity
- 37.1% Other, please specify:
- 2.9% No shipments monitored

46. Please describe any coordination efforts undertaken by your state with other state and/or federal agencies regarding the transportation of radioactive material.

47. What are the strengths of the current regulations on transporting radioactive materials?

48. What are the weaknesses of the current regulations on transporting radioactive materials?

30

49. Under current regulations, to what extent is the transportation of radioactive materials vulnerable to terrorist sabotage or other malicious use?

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IMPACT OF SEPTEMBER 11 TO YOUR STATE'S REGULATORY PROGRAM

50. What impact, if any, has the September 11, 2001 terrorist attacks had on your state's program in the following areas? (*Mark only one response ☒ in each row*)

	No Impact	Minor Impact	Moderate Impact	Significant Impact	No changes made since Sept 11, 2001
a) State radiological protection laws (N=33)	54.5%	15.2%	6.1%	3.0%	21.2%
b) State radiological protection regulations (N=33)	39.4%	39.4%	9.1%	0.0%	12.1%
c) License review procedures (N=34)	20.6%	44.1%	23.5%	5.9%	5.9%
d) Inspection frequency (N=34)	55.9%	29.4%	8.8%	0.0%	5.9%
e) Inspection procedures (N=34)	17.6%	38.2%	38.2%	2.9%	2.9%
f) Number of enforcement actions (N=32)	71.9%	12.5%	12.5%	0.0%	3.1%
g) Severity of enforcement actions taken (N=34)	60.6%	21.2%	15.2%	0.0%	3.0%
h) Incident response procedures (N=34)	14.7%	35.3%	32.4%	14.7%	2.9%
i) Incident investigation procedures (N=34)	20.6%	47.1%	20.6%	5.9%	5.9%
j) Coordination with federal agencies (N=34)	2.9%	23.5%	44.1%	23.5%	5.9%
k) Coordination with other states (N=34)	29.4%	35.3%	26.5%	2.9%	5.9%
l) Coordination with state law enforcement/public safety agencies (N=34)	2.9%	32.4%	38.2%	26.5%	0.0%
m) Financial support from state legislature (N=33)	63.6%	9.1%	0.0%	6.1%	21.2%
n) Monitoring of transportation of radioactive material through your state (N=33)	45.5%	18.2%	27.3%	6.1%	3.0%
o) Federal financial aid to your state program (N=33)	63.6%	9.1%	3.0%	3.0%	21.2%
p) Federal training support to your state program (N=33)	60.6%	21.1%	9.1%	0.0%	18.2%
q) Federal technology support to your state program (N=33)	57.6%	21.2%	3.0%	0.0%	18.2%

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51. Please describe specific efforts that have been initiated or considered by your state since September 11, 2001, to better safeguard radiological sources.

52. In your opinion, should post-September 11 security measures be developed and enforced by the NRC under the common defense and security authority given it by the Atomic Energy Act or by the agreement states under their health and safety authority? Why? (N=34)

    States = 82.4%; NRC = 5.9%; Both = 11.8%

53. Does your state have sufficient resources to support these new efforts or are additional resources needed? (N=35)

    Yes = 34.3%; No = 65.7%

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CHANGES NEEDED AT THE FEDERAL LEVEL

54. In your opinion, what are the 3 most significant changes (in rank order) that could be made at the federal level to improve the regulation of radioactive material to protect ***public health and safety***?

    #1.

    #2.

    #3.

55. In your opinion, what are the 3 most significant changes (in rank order) that could be made at the federal level to improve the ***security*** of radioactive material?

    #1.

    #2.

    #3.

56. In your opinion, what are the 3 most significant changes (in rank order) that could be made at the federal level to improve the ***transportation*** of radioactive material?

    #1.

    #2.

    #3.

57. Please use the space below to list any additional information about issues related to radioactive sources or concerns raised in this survey.

Thank you for your assistance in our survey.

Appendix V

Results of Survey of Non-Agreement States

GAO
Accountability * Integrity * Reliability

United States General Accounting Office

Non-Agreement State Survey on Security of Radioactive Sources

Background

The U.S. General Accounting Office (GAO), the investigative arm of Congress, is reviewing the regulation of radioactive materials in the United States. Congress has asked the GAO to answer the following questions:

1. What is the known universe of radiological sources in the United States and how many have been lost, stolen, or abandoned?

2. How effective are federal and state controls over radiological sources?

3. What efforts are underway since September 11, 2001, to improve the controls over radiological sources?

As part of our review, we are conducting surveys of state radiation control agencies, including agreement and non-agreement states, Puerto Rico, Guam, and the District of Columbia. The principal aims of this survey are to obtain information from each state on the number and types of radiological sources being regulated by the state and obtain states' views on the effectiveness of the current federal and state regulatory framework.

Your cooperation in completing this survey is essential for an accurate and timely report to the Congress on the current state of regulatory control over radioactive materials. To be included in our report, your response within 3 weeks of receipt is greatly appreciated.

Directions for Completing this Questionnaire

Please complete this questionnaire and return it via email (**ColesR@gao.gov**), fax (**202-512-6880**), or FedEx within 3 weeks of receipt. GAO will take steps to safeguard the privacy of your responses.

If you have any questions about the survey, please contact:

Ryan T. Coles
Office: 202-512-6888
E-mail: ColesR@gao.gov

Peter Ruedel
Office: 202-512-8753
E-mail: RuedelP@gao.gov

Heather Von Behren
Office: 202-512-6768
E-mail: VonBehrenH@gao.gov

If you prefer to return the survey via FedEx, the return address is:

U.S. General Accounting Office
Attention: Ryan T. Coles
Natural Resources and Environment
441 G Street, NW Room 2T23
Washington, DC 20548

Due to increased security put in place following the anthrax incidents of October 2001, please do not use the U.S. Postal Service to return surveys to GAO.

Although this questionnaire may require input from various individuals, we ask that one person assume responsibility for coordinating its completion. Please list that person's name below in case we have questions or need follow-up. Thank you.

Name:

Title:

Telephone #:

E-mail:

1

PROGRAM INFORMATION

1. **First, we'd like to get some basic information about your state's radiation control program. Please provide the following information.**

   Program name:

   State department/division/office (e.g. Department of Health):

   City the main office is located in:

   State:

   Current director of program:

2. **Please list your program's total budget for the following calendar years:**

2000 (Actual)	**$3,825,733 (N=10)**
2001 (Actual)	**$4,340,987 (N=10)**
2002 (Actual)	**$4,661,911 (N=10)**
2003 (Projected)	**$5,331,768 (N=11)**

3. **What are the sources of your program's funding? (*Mark all that apply* ☒) (N=12)**

   50.0% Fees charged to licensees
   83.3% Appropriations from state general fund
   50.0% Other, please specify:

4. **How many full-time equivalent (FTE) staff does your program currently employ? (N=12)**

   92

5. **Of the total number of staff reported in question #3, how many FTEs do you have in the following categories?**

Category of Staff	Number
Inspectors	
License reviewers	
Other Technical Staff	
Other Non-Technical Staff	

6. **How many of your technical staff (including inspectors and license reviewers) are professionally certified (e.g. certified health physicists, nuclear medicine technologists, etc.)?**

7. **How many staff were employed in your state in the following categories on January 1, 1998? (N=12)**

Category of Staff	Number on January 1, 1998
Inspectors	
License reviewers	
Other Technical Staff	
Other Non-Technical Staff	
TOTAL*	**90**

8. **Over the next five years, do you estimate your total full-time equivalent positions will increase or decrease for technical and non-technical staff?** ***(Mark only one response ☒ for each type of staff)***

Technical Staff (N=12)		Non-Technical Staff (N=11)	
16.7%	Increase	9.1%	Increase
8.3%	Decrease	0.0%	Decrease
75.0%	Stay about the same	90.9%	Stay about the same

3

LICENSING ACTIVITIES OF THE NON-AGREEMENT STATES

9. As of December 31, 2002, how many active licenses are currently issued by your state program for the production and/or use of naturally occurring or accelerator produced radioactive materials (N=12)

2751

10. Next, we would like to obtain information on licenses issued by your program for uses of naturally occurring radioactive material and accelerator produced radioactive material ***Enter the license use, mark whether it is for naturally occurring OR accelerator produced radioactive material, and enter the number of active licenses issued by your state program. Mark only one response ☒ in the column for most common inspection frequency within each license use.***

Use #1:

Type of Material	Number of licenses	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

Use #2:

Type of Material	Number of licenses	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

4

Use #3:

Type of Material	Number of licenses	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

Use #4:

Type of Material	Number of licenses	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

Use #5:

Type of Material	Number of licenses	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

5

Use #6:

Type of Material	Number of licensees	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

Use #7:

Type of Material	Number of licensees	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

Use #8:

Type of Material	Number of licensees	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

Use #9:

Type of Material	Number of licensees	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

Use #10:

Type of Material	Number of licensees	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

Use #11:

Type of Material	Number of licensees	Most Common Inspection Frequency Within This Code
☐ Naturally occurring		☐ More than once per year
☐ Accelerator produced		☐ Once a Year
		☐ Every 2-3 Years
		☐ Every 4-5 Years
		☐ Over 5 Years
		☐ Inspection Not Required

Please copy and paste above table for additional uses.

7

11. In your opinion, which 3 uses of radioactive materials—byproduct, naturally occurring, or accelerator produced—require the strictest and least strict regulation to protect *public health and safety*?

Strictest regulation	Least strict regulation
1.	1.
2.	2.
3.	3.

12. In your opinion, which 3 uses of radioactive materials—byproduct, naturally occurring, or accelerator produced—require the strictest and least strict regulation to ensure *security*? (i.e. to prevent the materials' use by terrorists in a radiological weapon)

Strictest regulation	Least strict regulation
1.	1.
2.	2.
3.	3.

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LICENSE TRACKING OVERSIGHT

13. Briefly describe how your program maintains data on materials licenses and inspections.

14. Please estimate the percentage of inspections of your licensees that are currently overdue.

15. Are your databases (i.e. licensing records, computer files containing licensee information) periodically validated to ensure that licensees are still active (i.e. still conducting business)? *Mark only one response* ☒) (N=11)

81.8%	Yes
18.2%	No *(skip to question 18)*

16. How often do you validate your databases? *Mark only one response* ☒) (N=9)

11.0%	More than once per year
33.3%	Once a year
44.4%	Every 2-3 years
11.1%	Every 4-5 years
0.0%	Over 5 years

17. What steps are taken to validate information in your databases?

18. Does your state have a program to identify and recover abandoned sources? *Mark only one response* ☒) (N=12)

33.3%	Yes
66.7%	No *(skip to question 20)*

19. Briefly describe your state's program to identify and recover abandoned sources.

10

ENFORCEMENT ACTIONS

20. What enforcement actions are available to your state's program to ensure laws and regulations are followed? (*Mark all that apply* ☒) (N=12)

- 16.7% No enforcement actions available ***(skip to question 24)***
- 83.3% Notices of violation/citations
- 58.3% Fines/civil penalties
- 58.3% License suspension
- 66.7% License termination
- 58.3% Facility closure
- 25.0% Imprisonment/criminal penalties
- 0.0% Other, please specify:

21. Please complete the following table on your state program's enforcement activities over the past five years. If none, please enter "0" (zero):

	Number of enforcement actions per year				
Enforcement action	**1998**	**1999**	**2000**	**2001**	**2002**
Notices of violation only (without other action)	302 (N=9)	340 (N=9)	265 (N=9)	303 (N=9)	519 (N=10)
Fines/civil penalties	5 (N=6)	4 (N=6)	7 (N=6)	10 (N=6)	7 (N=6)
License suspension	0 (N=7)	0 (N=7)	0 (N=7)	1 (N=7)	0 (N=7)
License termination	0 (N=6)	0 (N=6)	0 (N=6)	1 (N=6)	2 (N=7)
Facility closure	0 (N=6)	0 (N=6)	0 (N=6)	0 (N=6)	0 (N=6)
Imprisonment/criminal penalties	0 (N=5)	0 (N=5)	0 (N=5)	0 (N=5)	0 (N=5)
Other:	0 (N=1)	0 (N=1)	0 (N=1)	1 (N=1)	0 (N=1)

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22. How are fines/civil penalties collected by your program utilized? (N=12)

16.7%	Available for use by the state radiation control program
41.7%	Deposited into state general fund
16.7%	Other, please specify:
33.3%	Not applicable

23. Please briefly describe any enforcement cases since January 1, 1998, that have been difficult to resolve, have generated above average public or press interest, have challenged your regulatory authority, or have or will result in high clean up costs financed by state or federal funds.

EFFECTIVENESS OF CONTROLS OVER RADIOACTIVE MATERIALS

24. To what extent, if at all, do you agree that communications and coordination needs to be improved between your state program and the following group(s)? (*Mark only one response* ☒ *in each row*) (N=12)

Group	Very great extent	Great extent	Moderate extent	Some Extent	Little or no extent	No Basis to Judge
a) the U.S. Nuclear Regulatory Commission (NRC)	0.0%	8.3%	16.7%	8.3%	66.7%	0.0%
b) the U.S. Department of Energy (DOE)	8.3%	16.7%	41.7%	25.0%	8.3%	0.0%
c) the Environmental Protection Agency (EPA)	8.3%	16.7%	8.3%	41.7%	25.0%	0.0%
d) the Food and Drug Administration (FDA)	0.0%	16.7%	0.0%	41.7%	41.7%	0.0%
e) the U.S. Department of Justice (DOJ)	8.3%	25.0%	0.0%	25.0%	8.3%	33.3%
f) the U.S. Department of Transportation (DOT)	8.3%	16.7%	8.3%	41.7%	0.0%	25.0%
g) agreement states	0.0%	8.3%	8.3%	33.3%	25.0%	25.0%
h) other non-agreement states	0.0%	8.3%	16.7%	33.3%	16.7%	25.0%
i) Organization of Agreement States (OAS)	0.0%	8.3%	0.0%	16.7%	50.0%	25.0%
j) Conference of Radiation Control Program Directors (CRCPD)	0.0%	0.0%	0.0%	25.0%	75.0%	0.0%

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25. To what extent, if at all, do you agree with the following statement? ***(Mark only one response ☒ in each row)*** **(N=12)**

Group	Very great extent	Great extent	Moderate extent	Some Extent	Little or no extent	No Basis to Judge
a) Communications and coordination needs to be improved between federal agencies with regulatory authority for radioactive materials	8.3%	33.3%	0.0%	50.0%	0.0%	8.3%
b) The current division of regulatory authority for radioactive materials between NRC, DOE, EPA, DOT and FDA is the most effective means of federal regulation	0.0%	8.3%	8.3%	25.0%	50.0%	8.3%
c) Consistent radiation protection standards need to be developed that would apply across all federal and state regulatory programs.	50.0%	8.3%	8.3%	83.3%	0.0%	0.0%
d) My state program *currently* has sufficient budgetary resources to effectively regulate radiological sources	0.0%	8.3%	8.3%	0.0%	33.3%	0.0%
e) My state program *currently* has sufficient technology (e.g. radiation survey meters, laboratory resources) to effectively regulate radiological sources	8.3%	16.7%	41.7%	0.0%	33.3%	0.0%
f) My state program *currently* has ***sufficient*** personnel to effectively regulate radiological sources	0.0%	16.7%	0.0%	8.3%	75.0%	0.0%
g) My state program *currently* has ***qualified*** personnel to effectively regulate radiological sources	8.3%	33.3%	16.7%	33.3%	8.3%	0.0%
h) NRC's Nuclear Materials Events Database (NMED) accurately and completely reflects incidents involving radioactive materials in my state	8.3%	8.3%	16.7%	25.0%	0.0%	41.7%

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Group	Very great extent	Great extent	Moderate extent	Some Extent	Little or no extent	No Basis to Judge
i) DOT's regulations adequately ensure safe and secure transport of radioactive materials	16.7%	33.3%	16.7%	16.7%	8.3%	8.3%
j) The federal government should have a greater role in regulating radioactive material in the United States	16.7%	0.0%	25.0%	16.7%	33.3%	8.3%
k) Additional federal training could improve regulation of radioactive material in my state	33.3%	25.0%	16.7%	25.0%	0.0%	0.0%
l) My state's public safety/law enforcement agencies need additional training to respond to radiological incidents	50.0%	8.3%	33.3%	8.3%	0.0%	0.0%
m) My state program can effectively respond to a radiological incident with its current resources	0.0%	16.7%	41.7%	33.3%	8.3%	0.0%
n) In the event of a major radiological incident, adequate federal resources can be brought to bear in a timely manner	8.3%	0.0%	58.3%	8.3%	16.7%	8.3%
o) My state program is adequately addressing the post-September 11th heightened security concerns involving malicious use of radioactive material (i.e. possible use as a "dirty bomb")	0.0%	0.0%	25.0%	41.7%	33.3%	0.0%
p) *Over the next five years*, my state program will have sufficient budgetary resources to effectively regulate radiological sources	0.0%	8.3%	16.7%	0.0%	66.7%	8.3%
q) *Over the next five years*, my state program will have sufficient technology (e.g. radiation survey meters, laboratory resources) to effectively regulate radiological sources	0.0%	25.0%	25.0%	16.7%	25.0%	8.3%

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Group	Very great extent	Great extent	Moderate extent	Some Extent	Little or no extent	No Basis to Judge
r) *Over the next five years*, my state program will have ***sufficient*** personnel to effectively regulate radiological sources	0.0%	8.3%	0.0%	8.3%	75.0%	8.3%
s) *Over the next five years*, my state program will have ***qualified*** personnel to effectively regulate radiological sources	0.0%	8.3%	33.3%	25.0%	25.0%	8.3%

26. Please fill in the following table on the number of reportable incidents (under your state regulations, if any) involving naturally occurring or accelerator produced radiological materials that have occurred in your state from 1998 through 2002. If no incidents, please enter "0" (zero).

Type of Incident	Number of Incidents per year				
	1998	1999	2000	2001	2002
Equipment malfunction	0 (N=7)	0(N=7)	0(N=7)	0(N=7)	0(N=7)
Radiation overexposure	0 (N=7)	0(N=7)	2 (N=8)	2(N=7)	1(N=7)
Lost, stolen, or abandoned materials	26 (N=9)	32(N=9)	13 (N=10)	18 (N=10)	19 (N=10)
Medical events	6 (N=7)	4 (N=7)	0 (N=8)	2 (N=8)	5 (N=8)
Transportation events	16 (N=8)	23 (N=8)	9 (N=8)	10 (N=9)	5 (N=8)
Leaking sealed sources	1 (N=7)	0 (N=7)	0 (N=7)	0 (N=7)	0 (N=7)
TOTAL	115 (N=11)	140 (N=11)	89 (N=11)	94 (N=11)	109 (N=12)

27. For those materials that have been reported lost, stolen, or abandoned from 1998 through 2002, how many were subsequently recovered? (N=12)

10

NON-AGREEMENT STATE PERFORMANCE EVALUATION

28. Do you conduct periodic internal evaluations of your program's effectiveness? (*Mark only one response* ☒) (N=12)

66.7%	Yes
33.3%	No

29. Does an outside party (i.e. consultants or auditors) regularly evaluate your program? (*Mark only one response* ☒) (N=12)

8.3%	Yes
91.7%	No

TRANSPORTATION OF RADIOACTIVE MATERIALS

30. Does your program regulate the transportation of radioactive material through your state? (N=12)

25.0%	Yes
75.0%	No

31. Do you require licensees to notify your program of shipments of radioactive material? (N=12)

16.7%	Yes
83.3%	No *(skip to question 34)*

32. If yes, which types of cargo do you require that your program be notified of shipments of?

33. Which of the following types of shipments does your state monitor?

100%	Spent nuclear fuel
85.7%	DOE waste material (i.e. shipments to the Waste Isolation Pilot Plant)
100%	Byproduct material with high radioactivity
62.5%	Other, please specify:

34. Please describe any coordination efforts undertaken by your state with other state and/or federal agencies regarding the transportation of radioactive material.

35. What are the strengths of the current regulations on transporting radioactive materials?

36. What are the weaknesses of the current regulations on transporting radioactive materials?

37. Under current regulations, to what extent is the transportation of radioactive materials vulnerable to terrorist sabotage or other malicious use?

IMPACT OF SEPTEMBER 11 TO YOUR STATE'S REGULATORY PROGRAM

38. What impact, if any, has the September 11, 2001 terrorist attacks had on your state's program in the following areas? (*Mark only one response ☒ in each row*) (N=12)

	No Impact	Minor Impact	Moderate Impact	Significant Impact	No changes made since Sept 11, 2001
a) State radiological protection laws	50.0%	8.3%	0.0%	0.0%	41.7%
b) State radiological protection regulations	58.3%	8.3%	0.0%	0.0%	33.3%
c) License review procedures	41.7%	8.3%	16.7%	0.0%	33.3%
d) Inspection frequency	54.6%	9.1%	0.0%	9.1%	27.3%
e) Inspection procedures	41.7%	8.3%	8.3%	0.0%	41.7%
f) Number of enforcement actions	66.7%	0.0%	0.0%	0.0%	33.3%
g) Severity of enforcement actions taken	66.7%	0.0%	0.0%	0.0%	33.3%
h) Incident response procedures	16.7%	16.7%	8.3%	41.7%	16.7%
i) Incident investigation procedures	16.7%	8.3%	33.3%	16.7%	25.0%
j) Coordination with federal agencies	8.3%	41.7%	8.3%	25.0%	16.7%
k) Coordination with other states	25.0%	25.0%	16.7%	8.3%	25.0%
l) Coordination with state law enforcement/public safety agencies	16.7%	33.3%	8.3%	33.3%	8.3%
m) Financial support from your state legislature	58.3%	0.0%	0.0%	0.0%	41.7%
n) Monitoring of transportation of radioactive material through your state	33.3%	25.0%	8.3%	0.0%	33.3%
o) Federal financial aid to your state program	41.7%	8.3%	16.7%	0.0%	33.3%
p) Federal training support to your state program	50.0%	16.7%	16.7%	0.0%	16.7%
q) Federal technology support to your state program	58.3%	8.3%	8.3%	0.0%	25.0%

39. Please describe specific efforts that have been initiated or considered by your state since September 11, 2001, to better safeguard radiological sources.

40. Does your state have sufficient resources to support these new efforts or are additional resources needed? (N=12)

91.6% of states responding to the survey indicated they do not have sufficient resources to support new efforts.

8.3% of states responding to the survey indicated they have sufficient resources to support new efforts.

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CHANGES NEEDED AT THE FEDERAL LEVEL

41. **In your opinion, what are the 3 most significant changes (in rank order) that could be made <u>at the federal level</u> to improve the regulation of radioactive material to protect <u>*public health and safety*</u>?**

    #1.

    #2.

    #3.

42. **In your opinion, what are the 3 most significant changes (in rank order) that could be made <u>at the federal level</u> to improve the <u>*security*</u> of radioactive material?**

    #1.

    #2.

    #3.

43. **In your opinion, what are the 3 most significant changes (in rank order) that could be made <u>at the federal level</u> to improve the <u>*transportation*</u> of radioactive material?**

    #1.

    #2.

    #3.

44. Please use the space below to list any additional information about issues related to radioactive sources or concerns raised in this survey.

Thank you for your assistance in our survey.

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Appendix VI

Comments from the Nuclear Regulatory Commission

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 26, 2003

Mr. Robert A. Robinson
Managing Director, Natural Resources and Environment
United States General Accounting Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Robinson:

I would like to thank you for the opportunity to review and submit comments on the draft report, "NUCLEAR SECURITY: Federal and State Action Needed to Improve Security of Sealed Radioactive Sources" (GAO-03-804).

We believe the draft report does not fully present either the current status of our efforts to improve the security of high-risk radioactive sources or the large effort that we have devoted to this issue over the past eighteen months. It also reflects a limited outline of our existing statutory framework and does not recognize that several of its recommendations would require statutory changes at both Federal and State levels.

This report perpetuates one of the main problems of an earlier GAO report (GAO-03-638), namely its failure to focus on high-risk radioactive sources, which are of greatest concern for malevolent use by a terrorist. As I wrote you in commenting on that report, the vast majority of radioactive sources in use in the United States and abroad are not useful to terrorists. For example, iodine-131 and technetium-99m should not be included in any list of radionuclides of concern, as your draft report does in two places.

The Commission has already done the following to improve the security of high-risk radioactive sources:

1) Together with the Department of Energy (DOE) we have defined the radionuclides of concern and action levels for those radionuclides. Working with appropriate Federal agencies, particularly the Department of State (DOS), we have sought to reconcile the DOE/NRC definition of high-risk radioactive sources with that being developed by the International Atomic Energy Agency (IAEA) in its draft TECDOC-1344. We believe that international consensus will soon be reached on TECDOC-1344 so that we can reach international consistency on this critical definition.

2) We, together with DOE and DOS, have ensured that the United States has taken a leadership role in developing the draft IAEA Code of Conduct on Safety and Security of Radioactive Sources, a document which we hope will be finalized at the September IAEA General Conference Meeting.

3) The Commission has issued numerous advisories on security of sources, the most important of which was the advisory issued on March 17, 2003, at the initiation of Operation Liberty Shield. Working with our Agreement State colleagues, we assembled a list of approximately 2100 NRC or Agreement State licensees whose licenses permit them to possess greater than NRC/DOE action level quantities of the radionuclides of concern, and promptly issued the advisory to them. That advisory specified the

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additional security measures which we felt appropriate with the Nation at the orange threat level.

4) The Commission issued an Order to large panoramic irradiators on June 6, 2003, the detailed security measures of which are safeguards information under Section 147 of Atomic Energy Act.

5) The Commission has established a Materials Security Working Group involving both the Agreement States and the Conference of Radiation Control Program Directors (CRCPD) to ensure close coordination in the development of additional security orders to those licensees possessing category 1 or 2 quantities of radionuclides of concern as defined in TECDOC-1344 (a slight variation from the DOE/NRC action levels) and to deal with other materials security issues. The Commission discussed resolution of this issue with the leadership of the Organization of Agreement States (OAS) and CRCPD on June 6, 2003.

The Commission has plans in place to do the following:

1) In the very near term the Commission, in partnership with the Agreement States, will determine an initial inventory of high-risk radioactive sources (e.g., sources containing category 1 and 2 quantities of radionuclides of concern as defined in the latest version of TECDOC-1344) in the possession of all NRC and Agreement State licensees.

2) The Commission will develop a requirement for tracking such sources, as envisioned in the draft IAEA Code of Conduct on Safety and Security of Radioactive Sources.

3) The Commission will develop, in consultation with DOS and other agencies, an export and import control system for high-risk radioactive sources, again as envisioned in the IAEA Code of Conduct, and ensure the compatibility of our system with those of other countries.

The Commission fully recognizes that cooperation with our Agreement State colleagues is vital to the success of our efforts. The Commission must also work within the existing statutory framework. That framework reserves to the Commission the common defense and security authorities of the Atomic Energy Act. Moreover, section 147 of the Atomic Energy Act permits only the Commission, not the States, to prescribe that detailed security measures to protect byproduct material or special nuclear material be protected as safeguards information. These considerations have guided the Commission's approach to the security of high-risk sources in Agreement States. The possibility of State budget shortfalls played absolutely no role in the Commission's decision-making.

We have issued the June 5, 2003 Order to panoramic irradiator licensees based on the existing statutory framework. These additional security measures go beyond what would be required in a safety framework; they are actually done under common defense and security.

The Commission is not opposed to potential changes in our statutory framework and will explore such changes in the Materials Security Working Group. However, we are also not prepared to advocate any such changes today. Any changes at the Federal level will almost certainly entail change in State laws. Any such effort to amend statutes at both the Federal and

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State levels will take time. In the meantime, the Commission intends to work with the States to the maximum extent possible under existing statutes and in particular to utilize agreements pursuant to section 274i of the Atomic Energy Act to contract with the Agreement States for assistance in security inspections.

The enclosure provides specific comments on these matters . Should you have any questions about the NRC's comments, please contact either Mr. William Dean, at (301) 415-1703, or Ms. Melinda Malloy, at (301) 415-1785, of my staff.

Sincerely,

William Travers

William D. Travers
Executive Director
for Operations

Enclosure: Specific Comments on Draft Report GAO-03-804

cc: Ryan Coles, GAO

GAO Contact and Staff Acknowledgments

GAO Contact

Gene Aloise (202) 512-6870

Acknowledgments

In addition to the individual named above, Ryan T. Coles, Robert G. Crystal, Doreen S. Feldman, Judy K. Pagano, Terry L. Richardson, Peter E. Ruedel, Rebecca Shea, and Heather W. Von Behren also made key contributions to this report.

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United States General Accounting Office

GAO

Report to Congressional Requesters

September 2003

NUCLEAR REGULATORY COMMISSION

Oversight of Security at Commercial Nuclear Power Plants Needs to Be Strengthened

GAO

Accountability * Integrity * Reliability

GAO-03-752

September 2003

NUCLEAR REGULATORY COMMISSION

Oversight of Security at Commercial Nuclear Power Plants Needs to Be Strengthened

GAO
Accountability·Integrity·Reliability

Highlights

Highlights of GAO-03-752, a report to congressional requesters

Why GAO Did This Study

The September 11, 2001, terrorist attacks intensified the nation's focus on national preparedness and homeland security. Among possible terrorist targets are the nation's nuclear power plants—104 facilities containing radioactive fuel and waste. The Nuclear Regulatory Commission (NRC) oversees plant security through an inspection program designed to verify the plants' compliance with security requirements. As part of that program, NRC conducted annual security inspections of plants and force-on-force exercises to test plant security against a simulated terrorist attack. GAO was asked to review (1) the effectiveness of NRC's security inspection program and (2) legal challenges affecting power plant security. Currently, NRC is reevaluating its inspection program. We did not assess the adequacy of security at the individual plants; rather, our focus was on NRC's oversight and regulation of plant security.

What GAO Recommends

GAO is making recommendations to strengthen NRC's oversight at commercial nuclear power plants by promptly restoring annual security inspections and revising force-on-force exercises. NRC disagreed with many of GAO's findings, but did not comment on GAO's recommendations. GAO continues to believe its findings are appropriate and the recommendations need to be acted upon.

www.gao.gov/cgi-bin/getrpt?GAO-03-752.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells at (202) 512-3841 or wellsj@gao.gov.

What GAO Found

NRC has taken numerous actions to respond to the heightened risk of terrorist attack, including interacting with the Department of Homeland Security and issuing orders designed to increase security and improve plant defensive barriers. However, three aspects of its security inspection program reduced NRC's effectiveness in overseeing security at commercial nuclear power plants.

First, NRC inspectors often used a process that minimized the significance of security problems found in annual inspections by classifying them as "non-cited violations" if the problem had not been identified frequently in the past or if the problem had no direct, immediate, adverse consequences at the time it was identified. Non-cited violations do not require a written response from the licensee and do not require NRC inspectors to verify that the problem has been corrected. For example, guards at one plant failed to physically search several individuals for metal objects after a walk-through detector and a hand-held scanner detected metal objects in their clothing. The unchecked individuals were then allowed unescorted access throughout the plant's protected area. By making extensive use of non-cited violations for serious problems, NRC may overstate the level of security at a power plant and reduce the likelihood that needed improvements are made.

Second, NRC does not have a routine, centralized process for collecting, analyzing, and disseminating security inspections to identify problems that may be common to plants or to provide lessons learned in resolving security problems. Such a mechanism may help plants improve their security.

Third, although NRC's force-on-force exercises can demonstrate how well a nuclear plant might defend against a real-life threat, several weaknesses in how NRC conducted these exercises limited their usefulness. Weaknesses included using (1) more personnel to defend the plant during these exercises than during a normal day, (2) attacking forces that are not trained in terrorist tactics, and (3) unrealistic weapons (rubber guns) that do not simulate actual gunfire. Furthermore, NRC has made only limited use of some available improvements that would make force-on-force exercises more realistic and provide a more useful learning experience.

Even if NRC strengthens its inspection program, commercial nuclear power plants face legal challenges in ensuring plant security. First, federal law generally prohibits guards at these plants from using automatic weapons, although terrorists are likely to have them. As a result, guards at commercial nuclear power plants could be at a disadvantage in firepower, if attacked. Second, state laws vary regarding the permissible use of deadly force and the authority to arrest and detain intruders, and guards are unsure about the extent of their authorities and may hesitate or fail to act if the plant is attacked.

Contents

Abbreviations

DOE	Department of Energy
NRC	Nuclear Regulatory Commission
OSRE	Operational Safeguards Response Evaluation

GAO
Accountability * Integrity * Reliability

United States General Accounting Office
Washington, D.C. 20548

September 4, 2003

The Honorable John D. Dingell
Ranking Minority Member
Committee on Energy and Commerce
House of Representatives

The Honorable Edward J. Markey
House of Representatives

The September 11, 2001, terrorist attacks on the World Trade Center and the Pentagon intensified the nation's focus on national preparedness and homeland security. Among possible terrorist targets are the nation's commercial nuclear power plants—104 facilities containing radioactive fuel and waste operating in 32 states. The Nuclear Regulatory Commission (NRC) licenses commercial nuclear power plants and requires the licensee, among other things, to protect the plants against a potential terrorist threat. The design basis threat—which NRC develops for these facilities—delineates the maximum number of terrorists that NRC expects plants to defend against, the extent of their training, and the weapons and tactics they could use.

To ensure that commercial nuclear power plants can be protected against the design basis threat and meet other security requirements, NRC requires each licensee to have an NRC-reviewed and -approved security plan before NRC allows the plant to operate. After the plant begins operations, NRC oversees plant security through an inspection program designed to verify that the plant continues to meet security requirements. As part of the security inspection program, NRC conducts annual security inspections of plants and conducts force-on-force exercises. During the security inspections, NRC reviews (1) the list of those who have access to the plant, (2) the plant's response to an unusual security event, (3) any changes to the security plan, and (4) samples of the plant's own assessment of its security. Since 1991, the inspection program has also included periodic force-on-force exercises, which are designed to simulate an attack on the plant that is based on the design basis threat. NRC also conducts nonrecurring inspection activities, such as special inspections to ensure that post-September 11, 2001, security enhancements have been implemented at each plant.

In 2001, NRC curtailed its annual security inspections and force-on-force exercises to redesign them for heightened security threats. Until the annual

security inspections are resumed sometime in 2004, NRC inspectors have been verifying that post-September 11, 2001, security improvements have been implemented at each plant and conducting special inspections if a serious problem is identified by the licensee in its quarterly self-assessment. In terms of force-on-force exercises, NRC is currently testing and evaluating these exercises under a pilot program that has resulted in five exercises being conducted since January 2003.

You asked us to review (1) the effectiveness of NRC's inspection program to oversee security at commercial nuclear power plants and (2) legal challenges currently affecting physical security at the power plants. We did not assess the adequacy of security at the nation's nuclear power plants. Rather, our focus was on NRC's oversight and regulation of plant security. In conducting our review, we analyzed NRC's inspection program from January 2000 through September 2001 and the force-on-force exercise program from January 1991 through September 2001. We also reviewed NRC's initiatives to enhance power plant security after September 11, 2001, as well as its efforts to ensure that the power plants implemented those initiatives. We met with NRC, the Department of Energy (DOE), and power plant representatives and obtained NRC advisories, orders, regulations, and inspections reports. To determine how NRC tests the power plants' security, we reviewed reports for 80 force-on-force exercises that NRC conducted through September 2001. We designed and completed a data collection instrument in order to organize specific elements that we extracted from these reports. We also held discussions with DOE officials to determine how they conduct force-on-force exercises at DOE's nuclear facilities and if there are any "promising practices" that might be applied to NRC's program. Finally, we obtained NRC's and industry officials' views on laws that could affect a licensee's ability to adequately secure commercial nuclear power plants. Appendix I contains a more detailed discussion of our scope and methodology.

Results in Brief

Since September 11, 2001, NRC has taken numerous actions to increase security at commercial nuclear power plants. However, three aspects of NRC's security inspection program have reduced its effectiveness in overseeing security at commercial nuclear power plants. First, during annual inspections, NRC inspectors often classified security problems as "non-cited violations" if the problem had not been identified frequently in the past or if the problem had no direct, immediate, adverse consequences at the time that it was identified. This classification tends to minimize the seriousness of the problems. Non-cited violations do not require a written

response from the licensee and do not require NRC inspectors to verify that each problem has been corrected. For example, guards at one plant failed to physically search several individuals for metal objects after a walk-through detector and a hand-held scanner detected metal objects in their clothing. The unchecked individuals were then allowed unescorted access throughout the plant's protected area. Although this incident appears serious, NRC issued a non-cited violation for it and rated the plant's security as meeting security objectives. Through its extensive use of non-cited violations, rather than reporting the problems as more serious cited violations, NRC may have overstated the level of security at power plants.

Second, NRC does not have a centralized process for routinely collecting, analyzing, and disseminating security inspections to identify problems that may be common to plants or to provide lessons learned in resolving a security problem. Third, although force-on-force exercises could demonstrate how well a nuclear plant might defend against a real-life threat, several weaknesses in how NRC conducted past exercises limited their usefulness. Specifically, (1) NRC conducted these exercises at each nuclear power plant once every 8 years; (2) the licensees used plant defenses during the exercises that were enhanced beyond those used during normal operations; (3) the attacking forces were not trained in terrorist tactics; (4) participants used unrealistic weapons (e.g., rubber guns instead of laser equipment, which would better simulate weapon fire); (5) exercises did not test the full extent of the design basis threat; and (6) exercise reports were often late. As a result, the exercises did not provide information on a power plant's ability to defend against the maximum design basis threat and permanent correction of problems may have been delayed. Furthermore, NRC has made only limited use of some available administrative and technological improvements that would make force-on-force exercises more realistic and provide a more useful learning experience.

Commercial nuclear power plants face legal challenges in ensuring physical plant security. First, federal law generally prohibits private citizens—including guards at these plants—from using automatic weapons, although terrorists are likely to have them. As a result, guards at commercial nuclear power plants could be at a disadvantage in firepower if attacked. Second, state laws vary regarding the permissible use of deadly force and the authority to arrest and detain intruders. According to NRC's force-on-force reports and NRC officials, plant guards are unsure about when and if they can use deadly force, and guards are unclear about what authority they have to arrest and detain intruders. As a result, guards may

hesitate or fail to take action if a plant comes under attack. NRC has recognized the impact of these federal and state laws on security and has sought federal legislation to address these legal challenges.

We are making recommendations to the NRC Commissioners to restore and strengthen NRC's oversight of security at commercial nuclear power plants—specifically, NRC's annual inspection program and force-on-force exercises. In reviewing a draft of this report, NRC did not comment on our conclusions and recommendations. NRC did comment that our report failed to reflect changes made to the program since September 11, 2001, and that the issues addressed in the report were relatively minor and were appropriately addressed. While we agree that NRC has taken many actions since September 11, we note that most of these actions related to enhancing security at the plants and did not relate to NRC's oversight efforts. In fact, since September 11, NRC has suspended the two major elements of its oversight program, baseline inspections and force-on-force exercises. We believe that the issues cited in this report, such as improperly screening individuals entering the plant, are not minor, and that promptly restoring the annual security inspections and force-on-force exercises will improve NRC's oversight responsibilities.

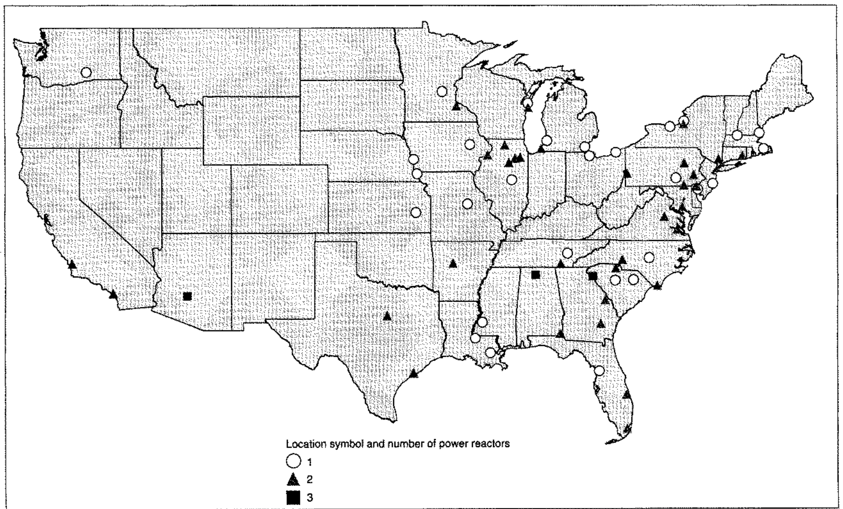
Background

NRC is an independent agency established by the Energy Reorganization Act of 1974 to regulate civilian use of nuclear materials. NRC is headed by a five-member commission. The President designates one commission member to serve as Chairman and official spokesperson. The commission as a whole formulates policies and regulations governing nuclear reactor and materials safety, issues orders to licensees, and adjudicates legal matters brought before it. Security for commercial nuclear power plants is primarily the responsibility of NRC's Office of Nuclear Security and Incident Response. This office develops overall agency policy and provides management direction for evaluating and assessing technical issues involving security at nuclear facilities, and it is NRC's safeguards and security interface with the Department of Homeland Security, the intelligence and law enforcement communities, DOE, and other agencies.[1] The office also develops and directs the NRC program for response to incidents, and it is NRC's incident response interface with the Federal Emergency Management Agency and other federal agencies. NRC

[1]DOE operates facilities that contain radioactive material used in its nuclear weapons program.

implements its programs through four regional offices. Figure 1 shows the location of commercial nuclear power plants operating in the United States. (See app. II for a list of the commercial nuclear power plants, their locations, and the NRC regions that are responsible for them.)

Figure 1: Commercial Nuclear Power Plants in the United States



Source: GAO analysis of NRC data.

Commercial nuclear power plants are also subject to federal and state laws that control certain matters related to security functions, such as the possession and use of automatic weapons by security guards and the use of deadly force.

NRC Security Regulation and Oversight

NRC begins regulating security at a commercial nuclear power plant when the plant is constructed. Before granting an operating license, NRC must approve a security plan for the plant. Since 1977, NRC has required the plants to have a security plan that is designed to protect against a design basis threat for radiological sabotage.[2] Details of the design basis threat are considered "safeguards information" and are restricted from public dissemination.[3] The design basis threat characterizes the elements of a postulated attack, including the number of attackers, their training, and the weapons and tactics they are capable of using. The design basis threat, revised twice since it was first issued in 1977, requires the plants to protect against "a determined violent external assault by stealth, or deceptive actions" or "an internal threat of an insider, including an employee in any position." Under the 1977 design basis threat, plants had to

- add barriers to vital equipment and work zones and develop identification and search procedures for anyone entering restricted areas;
- upgrade alarm systems and internal communication networks and control keys, locks, and combinations; and
- maintain a minimum number of guards, armed with semiautomatic weapons, that had to be on duty at all times (unless NRC granted an exemption that allowed fewer guards).

In 1993, in response to the first terrorist attack on the World Trade Center in New York City and to a vehicle intrusion at the Three Mile Island nuclear power plant in Pennsylvania, NRC revised the design basis threat for radiological sabotage to include the possible use of a vehicle bomb. This action required the installation of vehicle barriers at the power plants. On April 29, 2003, NRC issued a revised design basis threat that the commission believes is the "largest reasonable threat against which a regulated private guard force should be expected to defend under existing law." NRC has given the power plants 18 months to comply with the new design basis threat.

[2]Radiological sabotage against a nuclear power plant is a deliberate act that could directly or indirectly endanger the public health and safety by exposure to radiation.

[3]Safeguards information is unclassified sensitive information.

NRC's inspection program is an important element in its oversight effort to ensure that commercial nuclear power plants comply with security requirements. Security inspectors from the agency's four regional offices conduct annual inspections at each plant. These inspections are designed to check that the power plants' security programs meet NRC requirements in the areas of access authorization, access control, and response to contingency events. The inspections also involve reviewing changes to the plant's security plan and random samples of the plant's own assessment of its security. NRC suspended its inspection program in September 2001 to focus its resources on the implementation of security enhancements. NRC is currently revising the security inspection program.

NRC also conducted force-on-force exercises under the security inspection program. These force-on-force exercises, which were referred to as Operational Safeguards Response Evaluation (OSRE) exercises, were designed to test the adequacy of a plant's capability to respond to a simulated attack. NRC began conducting these exercises in 1991 but suspended them after September 11, 2001. NRC intends to restructure the program. It has recently begun a series of pilot force-on-force exercises that are designed to provide a more rigorous test of security at the plants and to provide information for designing a new force-on-force exercise program. No date has been set for completing the pilot program or for initiating a new, formal force-on-force program.

NRC Actions to Enhance Security at Commercial Nuclear Power Plants since September 11, 2001

In order to respond to the heightened risk of terrorist attack, NRC has had extensive interactions with the Department of Homeland Security and the Homeland Security Council on security at commercial nuclear power plants. NRC also has issued advisories and orders that were designed to increase the size and improve the proficiency of plant security forces, restrict access to the plants, and increase and improve plant defensive barriers. On October 6, 2001, NRC issued a major advisory, stating that the licensees should consider taking immediate action to increase the number of security guards and to be cautious of temporary employees. NRC conducted a three-phase security inspection, checking the licensees to see if they had complied with these advisories. Each licensee's resident inspector[4] conducted phase one, which was a quick overview of the licensee's security program using a headquarters-prepared survey. During

[4]NRC resident inspectors are stationed at each commercial nuclear power plant facility. The resident inspectors are not security specialists, focusing primarily on plant safety.

phase two, NRC's regional security inspectors conducted a more thorough survey of each plant's security. During phase three, which concluded in January 2002, NRC's regional security inspectors reviewed each licensee's security program to determine if the licensee had complied with the additional measures suggested in the October 6, 2001, advisory.

NRC used the results from the three-phase security inspection in developing its February 25, 2002, order requiring licensees to implement additional security mechanisms.[5] Many of the order's requirements were actions suggested in previous advisories. The licensees had until August 31, 2002, to implement these security requirements. In December 2002, NRC completed a checklist to provide assurance that the licensees had complied with the order. In addition, NRC developed a security inspection procedure to validate and verify licensee compliance with all aspects of the order. NRC estimates that this procedure will be completed by December 2003. On August 14, 2003, NRC stated that 75 percent of the power plants had been inspected for compliance with the order.

NRC also took action on an item that had been a security concern for a number of years—the use of temporary clearances for temporary workers. Commercial nuclear power plants use hundreds of temporary employees for maintenance—most frequently during the period when the plant is shut down for refueling. In the past, NRC found instances in which personnel who failed to report criminal records had temporary clearances that allowed them unescorted access to vital areas. [6] In its October 6, 2001, advisory, NRC suggested that licensees limit temporary clearances for temporary workers. On February 25, 2002, NRC issued an order that limited the use and duration of temporary clearances, and, on January 7, 2003, NRC issued an order to eliminate the use of these clearances.[7] NRC now requires a criminal history review and a background investigation to be completed before allowing temporary workers to have unescorted access to the power plants.

[5]NRC Order EA-02-026.

[6]The vital area, within the protected area, contains the plant equipment, systems, devices, or material whose failure, destruction, or release could endanger the public health and safety by exposure to radiation. This area is protected by guard stations, reinforced gates, surveillance cameras, and locked doors.

[7]NRC Order EA-02-261.

On April 29, 2003, in addition to issuing a new design basis threat, NRC issued two orders that are designed to ensure that excessive work hours do not challenge the ability of security forces in performing their duties and to enhance the training and qualification program for security forces.

Three Aspects of NRC's Security Inspection Program Inhibit Effective Oversight

NRC's security inspection program may not be fully effective because of weakness in three areas. First, during the annual inspections conducted from 1999 until September 2001, NRC's regional security specialists used a process to categorize the seriousness of security problems that, in some cases, minimized their significance. As a result, NRC did not track these problems to ensure that they had been permanently corrected and may have overstated the level of security at power plants. Second, NRC does not routinely collect and disseminate information from security inspections to NRC headquarters, other NRC regions, or other power plants. Dissemination of this information may help other plants to correct similar problems or prevent them from occurring. Third, NRC has made limited use of some available administrative and technological improvements that would make force-on-force exercises more realistic and provide a more useful learning experience.

NRC's Inspection Practices Minimize the Significance of Some Security Problems

NRC ensures that commercial nuclear power plants maintain security by monitoring the performance and procedures of the licensees that operate them. NRC's inspection program is the agency's only means to verify that these plants comply with their own NRC-approved security plans and with other NRC security requirements.

NRC suspended its annual security inspection program after September 11, 2001, and currently is revising the program. NRC does not expect a new security inspection program to be implemented until some time in 2004. Although NRC has temporarily suspended its annual security inspections, it continues to check a plant's self-assessments and conduct an inspection if the licensee identifies a serious problem.

Under the previous security inspection program, initiated in 1999 and suspended in 2001, NRC used a "risk informed" performance-based system (the Reactor Oversight Process) that was intended to focus both NRC's and the licensees' resources on important safety matters. In an attempt to focus NRC attention on plants with the most serious problems, and to reduce regulatory burdens on the nuclear industry, the Reactor Oversight Process

relied heavily on performance assessment data generated by the licensees and submitted quarterly to NRC. In the security area, these licensee self-assessments provided NRC with data on (1) the operation of security equipment (such as intrusion detectors and closed-circuit television cameras), (2) the effectiveness of the personnel screening program (including criminal history and background checks), and (3) the effectiveness of the employee fitness-for-duty program (including tests for substance abuse and behavioral observations). Under guidelines for these self-assessments, licensees are required to report only the most serious problems. NRC inspectors followed a multistep process to monitor security, including verifying the licensees' self-assessments and conducting their own annual inspection. NRC inspectors did not verify all aspects of the licensees' self-assessments. Instead, the inspectors made random checks of the quarterly self-assessments during their annual security inspection of the plant.

During the inspections, the inspectors reviewed the following aspects of security at each plant:

- *Access authorization and fitness for duty (performed annually).* Inspectors interviewed supervisors and their staffs about procedures for recognizing drug use, possession, and sale; indications of alcohol use and aberrant behavior; and records of testing for suspicious behavior. These procedures were designed to ensure that the licensee conducts adequate personnel screening and enforces fitness-for-duty requirements—functions considered critical to protect against an insider threat of radiological sabotage.

- *Access control (performed annually).* Inspectors observed guards at entry points during peak hours, checked screening equipment, read event reports and logs, checked access procedures for the plant's vital area, and surveyed data in the security computers. For example, inspectors observed searches of personnel, packages, and vehicles for contraband (i.e., firearms, explosives, or drugs) before entry into the protected area and ensured that the guards granted only authorized persons unescorted access to the protected and the vital areas of the plant.

- *Response to contingency events (performed triennially).*[8] Inspectors tested the licensee's physical security by testing the intrusion detection system.

- *Random checks of changes to security plans (performed biennially).* Under NRC regulations, licensees can change their security plans without informing NRC if they believe that the change does not decrease the effectiveness of the plan. Inspectors reviewed security plan changes and could have physically examined a change if an issue arose.

If NRC inspectors detected a security problem in these areas, they determined the problem's safety significance and whether it violated the plant's security plan or other NRC requirements. If a violation occurred, and the inspectors determined that the problem was "more than minor," they used a "significance determination process" to relate the violation to overall plant security. According to NRC officials, the significance determination process is also being revised. Under the process previously used, the inspectors assigned a violation one of the following four ratings: very low significance, low to moderate significance, substantial significance, and high significance. For violations more serious than very low significance, the licensee was required to prepare a written response, stating the actions it would take to correct the problem. However, violations judged to be of very low significance—usually categorized as non-cited violations—were routinely recorded; entered into the plant's corrective action plan; and, from NRC's perspective, closed. Violations were judged to be of low significance and categorized as a non-cited violation if the problem had not been identified more than twice in the past year or if the problem had no direct, immediate, adverse consequences at the time it was identified. In addition, for non-cited violations, NRC did not require a written response from the licensee and did not routinely follow up to ensure that a permanent remedy had been implemented unless the non-cited violation was randomly selected for review of the licensee's corrective action program.

We found that NRC frequently issued non-cited violations. NRC issued 72 non-cited security violations from 2000 to 2001 compared with no cited security violations during the same period. In addition, NRC issued non-cited violations for security problems that, while within NRC's guidance for

[8] A contingency event is any event that could impact on the security of the plant.

non-cited violations, appear to be serious and seem to justify the formality and follow-up of a cited violation. For example:

- At one plant, an NRC inspector found a security guard sleeping on duty for more than half an hour. This incident was treated as a non-cited violation because no actual attack had occurred during that time, and because neither he nor any other guard at the plant had been found sleeping more than twice during the past year.
- At another plant, a security officer falsified logs to show that he had checked vital area doors and barriers when he was actually in another part of the plant. The officer was the only protection for this area because of a "security upgrade project."
- At another plant, NRC inspectors categorized two security problems as non-cited violations because they had not occurred more than twice in the past year. In one incident, an inspector observed guards who failed to physically search several individuals for metal objects after a walk-through detector and a hand-held scanner detected metal objects in their clothing. The unchecked individuals were then allowed unescorted access throughout the plant's protected area. Also, security was compromised in a vital area—where equipment that could be required to protect public health and safety is located—when an inspector found that tamper alarms on an access door had been disabled. In this case, the only compensatory measure implemented was to have a guard check the location once during each 12-hour shift.

In addition to NRC's annual inspections, NRC will conduct an inspection if a plant's quarterly self-assessment identifies a serious security problem. Between 2000 and 2002, only 4 of the 104 plants reported security problems that required NRC to conduct a follow-up inspection. In 2000, each plant identified that equipment for controlling access to the plant's protected area was often broken, requiring extra guards as compensation. None of the 104 plants' self-assessments identified any security problems in 2001, 2002, or the first 6 months of 2003.

Once every 3 months, NRC develops performance summaries for each of the nuclear power plants it regulates. In the security area, NRC uses each plant's self-assessment performance indicators and its own annual inspections as the basis for each plant's quarterly rating. The performance rating can range from "meeting security objectives" to "unacceptable." The ratings are displayed on NRC's Web site, which is the public's main link to

NRC's assessment of the security at each plant. However, because of NRC's extensive use of non-cited violations, the performance rating may not always accurately represent the security level of the plant. For example, the plant where the sleeping guard was found was rated as meeting security objectives for that period. NRC also rated security as meeting objectives at the plant where physical searches were not conducted for metal detected by scanners.

NRC Does Not Systematically Collect, Analyze, and Disseminate Information That May Improve Security at All Plants

NRC does not have a routine, centralized process for collecting, analyzing, and disseminating security inspections to identify problems that may be common to other plants or to identify lessons learned in resolving a security problem that may be helpful to plants in other regions. NRC headquarters only receives inspection reports when a licensee challenges the findings from security inspections. Following the inspection, the regional security specialist prepares a report that is then sent to the licensee for comment. If the licensee does not challenge the report's findings, the report is filed at the region. If the licensee challenges the findings, a NRC headquarters security review panel meets to resolve the issue. At this point, headquarters security specialists may informally retain copies of the case, but, officially, headquarters returns the files to the region, which replies to the licensee.

According to NRC headquarters officials, they do not routinely obtain copies of all security inspection reports because headquarters files and computer databases are insufficient to hold all inspection reports. In addition, some of the reports contain safeguards information and can only be transferred by mail, courier, or secure fax. Instead, headquarters only has a list of reports in its computer database—not the narrative details that include safeguards information. According to headquarters officials, regional NRC security specialists may maintain their own information about security problems and their resolution, but they have not done this systematically nor have they routinely shared their findings with headquarters or the other regions.

NRC's Force-on-Force Exercises Are Limited in Their Usefulness

From 1991 through 2001, NRC conducted force-on-force exercises, called OSREs, at the nation's commercial nuclear power plants. Although these exercises have provided learning experiences for the plants and may have helped improve plant security, the exercises did not fully demonstrate the plants' security preparedness. The exercises were conducted infrequently, against plant security that was enhanced by additional guards and/or

security barriers, by simulated terrorists who were not trained to operate like terrorists, and with unrealistic weapons. In addition, the exercises did not test the maximum limits of the design basis threat, and inspectors often filed OSRE reports late. As a result, the exercises did not provide complete and accurate information on a power plant's ability to defend against the maximum limits of the design basis threat, and permanent correction of problems may have been delayed. Furthermore, NRC has made only limited use of some available administrative and technological improvements that would make force-on-force exercises more realistic and provide a more useful learning experience.

Exercises Were Conducted Infrequently

NRC was not required by law, regulation, or order to conduct OSRE exercises; however, NRC and the licensees believed that these exercises were an appropriate mechanism to test the adequacy of the plants' security plans, and all licensees agreed to participate in these exercises. Since there is no requirement, NRC started the OSRE program without guidance on how frequently the exercises should be conducted at each plant. NRC conducted OSRE exercises at each commercial nuclear power plant about once every 8 years. Sixty-eight power plant sites have conducted one OSRE exercise and 12 sites have conducted two exercises.

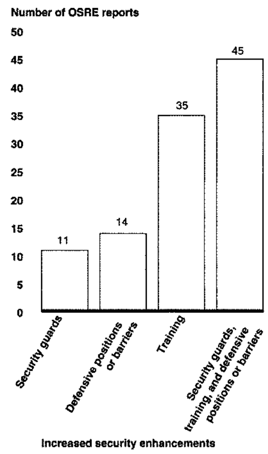
Like NRC, DOE conducts force-on-force exercises at its nuclear facilities.[9] DOE's regulations state that force-on-force exercises should be conducted at every facility once a year. According to DOE officials, annual inspections are important because DOE wants up-to-date information on security preparedness at each nuclear facility; and more frequent exercises require the facilities to maintain the quality of the security program because another drill is always only a few months away. According to NRC officials, they are planning to initiate a new force-on-force exercise program that will be based on ongoing pilot force-on-force exercises. They plan to conduct an exercise for each licensee every 3 years, which will require additional regional security inspectors.

[9]DOE's facilities differ from the commercial nuclear power plants that NRC oversees. Both of these types of facilities, however, contain radioactive material that must be protected. The security that is required to protect the facilities also differs; however, we believe that there are some similarities that allow for lessons learned or promising practices by one agency to have application by the other.

Exercises Were Conducted Against Enhanced Plant Defenses

According to NRC officials, they provided the licensee with up to 12 months' advance notice of OSRE exercises so that it could assemble a second team of security guards to protect the plant while the exercise was being conducted. However, the advanced notification also allowed licensees to enhance security prior to the OSRE exercises, and they were not required to notify NRC of any enhancements to their security plan. As a result, according to NRC officials, during the exercises, many plants increased the number of guards that would respond to an attack; added security barriers, such as additional fencing; and/or added defensive positions that they did not previously have. According to our review of all 80 OSRE reports, at least 45—or 56 percent—of the exercises were conducted against plant defenders who had received additional training for the exercise or against enhanced plant security features, such as additional guards or defensive positions or barriers. Figure 2 shows the number of OSRE reports that stated that the exercises were conducted against (1) guard forces that were larger than those provided for in the security plan; (2) increased defensive positions or barriers; (3) guards that had received additional training; and (4) guard forces that were larger than those provided for in the security plan, guards that had received additional training, or plants that had enhanced defensive positions or barriers.

Figure 2: Security Enhancements Made before OSRE Exercises



Source: GAO analysis of NRC OSRE reports.

Although we found 11 instances in which plants had increased the number of security guards for the OSRE exercises, an NRC official told us that the number was actually higher but was not reported in the OSRE reports. According to this official, 52 of the first 55 OSREs conducted used more guards than provided for in the plants' security plans. For these plants, the number of guards used exceeded the number called for in the security plan by an average of 80 percent. According to this official, using additional guards impaired the realism of the exercise because in the event of an actual attack, only the number of guards specified in the security plan would protect the plant.

Plants that used increased numbers of guards, increased training, or increased defensive positions or barriers fared better in the OSREs than those that used the plant defenses specified in the security plan. According to the OSRE reports, of the 45 plants that increased plant defenses beyond

the level specified in the security plan, 10 (or 22 percent) failed to defeat the attackers in one or more of the exercises conducted during the OSRE. However, of the 35 plants that used only the security levels specified in the security plan, 19 (or 54 percent) failed to defeat the attackers in one or more exercises conducted during the OSRE.

The increased training and preparation for the OSRE exercises provided an opportunity for the licensee to examine its security program and upgrade the program in areas found lacking. However, according to an NRC official, the licensee could decrease security to previous levels after the exercise. Consequently, the exercise only provided an evaluation of the "ramped up" security and provided little information on the plant's normal day-to-day security. According to this official, NRC could not hold a licensee accountable for ramping down after the OSRE exercise because the enhanced training and additional barriers were not part of the licensee's security plan, and NRC can only hold the licensee accountable for its security plan. NRC has not required that security enhancements implemented to prepare for OSRE exercises be included as part of the plants' security plans. However, as of November 2000, NRC no longer allowed the licensee to increase the number of guards or add defensive positions or security barriers for OSRE exercises. Between November 2000 and the suspension of the program in September 2001, only eight OSREs were conducted.

DOE—which also provides its facilities with advanced notice of a scheduled force-on-force exercise (up to 1 year) and allows the facility to upgrade its security for the exercise—requires that any enhancements to security that are implemented for the exercise become integrated into the facility's security plan. DOE inspectors conduct follow-up visits to verify that the enhancements have been maintained.

Adversary Forces Were Not Trained in Terrorist Tactics

Licensees used off-duty guards, guards from other licensees, and management personnel as the simulated adversary force for OSRE exercises, but these forces may not have accurately simulated the dangers of an attack. The guards on the adversary force had training only in defending the plant, not in terrorist and offensive tactics or in the use of weapons that a terrorist might have. Furthermore, plant managers participating in the drill had little or no training or experience, even in defensive tactics. Finally, some members of the adversary force could have a vested interest in having the licensee's guard force successfully defeat them in attempting simulated radiological sabotage, thereby demonstrating an adequate security program.

In contrast, DOE uses a trained, simulated composite adversary force in all of its force-on-force exercises. This force includes guards from all departmental facilities.[10] Team members are trained in offensive tactics and, according to DOE officials, have an "adversary" mind-set, which allows them to think and act like terrorists.

According to NRC officials, as part of the pilot program, they are assessing the characteristics, training, and selection of the adversary force. They said that they also have reviewed DOE's composite adversary team methods, attended DOE's adversary training school, and are assessing the DOE program's relevance to NRC activities.

Exercises Used Unrealistic Weapons

Adversary and plant defensive forces generally used rubber weapons during OSRE exercises. Although under some circumstances, such as very confined spaces, rubber weapons would be the most practical, in general, rubber weapons do not simulate actual gunfire or provide real-time experience. Licensee employees (controller judges) had to determine whether a guard or adversary member's weapon hit its intended target. This led to unrealistic exercises. For example, in one OSRE exercise, the controller judges reported that they could not determine when weapons were "fired" or if a person was hit.

DOE usually uses Multiple Integrated Laser Equipment to simulate weapon fire and provide real-time experiences. Multiple Integrated Laser Equipment consists of weapons-mounted laser transmitters and laser sensors on the guard forces and adversary team members. When a laser gun is fired and hits a target, an alarm registers the hit, thereby allowing the participants to simulate weapon fire and participate in real-time exchanges.

A few NRC OSRE exercises used Multiple Integrated Laser Equipment. According to one OSRE report, the use of laser guns provided realistic scenarios and simulated the stress of an actual engagement. Consequently, the exercise showed results that "significantly helped in evaluating the effectiveness of both the defensive strategy and the officers executing the strategies." NRC officials said that they are conducting a $1.4 million assessment of the use of Multiple Integrated Laser Equipment.

[10]DOE, Office of Independent Oversight and Performance Assurance, *Inside Oversight*, Special Edition, June 2002, 1-2.

Exercises Did Not Test the Full Extent of the Design Basis Threat

NRC never tested several aspects of the design basis threat in the OSRE exercises. As a result, NRC could not determine the plants' capability to defend against the maximum credible terrorist attack. According to the NRC official who was in charge of the OSRE program, NRC did not use and test certain adversary capabilities because the exercises would have been too rigorous, would have resulted in too many exercises in which the adversaries achieved their objectives, and thus may have resulted in the elimination of the OSRE program. The second round of OSRE exercises, begun in 2000, was originally planned to include all of the adversary capabilities. However, from the beginning of the second round of OSREs to the suspension of the program in September 2001, none of the OSREs included all adversary capabilities.

DOE tests the full adversary capabilities of the design basis threat and often goes beyond those capabilities. DOE officials believe it is important to test the licensee's security against all of the adversary capabilities so that DOE can determine how secure the facility is and what improvements are needed.

Operational Safeguards Response Evaluation Reports Were Not Timely

NRC had a program goal of issuing OSRE reports 30 to 45 days after the end of the exercise, but 46 of 76 reports (60 percent) were not issued within the required time.[11] Delays in releasing a report to the licensee may have affected the timeliness of permanent corrective actions and diminished the effectiveness of feedback on the exercise. On average, NRC issued OSRE reports to the licensees 98 days after the end of the exercises. The OSRE reports addressed any problems that needed to be corrected and specified how long the licensee had to correct the problem. NRC communicated the results of the exercise to the licensee at a closeout meeting. If a concern was severe and made the licensee vulnerable to security breaches, the licensee was required to provide temporary protection to address that concern until it implemented a permanent correction. However, the OSRE reports have specified an average of 51 days to permanently correct a concern after the report was issued. As a result, nearly 5 months elapsed between when the exercise was completed and when the report was issued and a permanent correction was required.

[11]Four of the 80 reports did not contain the information that was necessary to determine the time required to issue the report.

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Federal Law Limits the Type of Weapons That Guards Can Use, and State Laws Vary on Guards' Authority to Deal with Intruders

Commercial nuclear power plants face challenges in securing their plants against intruders because federal and state laws limit security guards' ability to defend these plants. Federal law generally prohibits private ownership of automatic weapons, and there is no exemption in the law for security guards at commercial nuclear power plants.[12] As a result, no nuclear power plants use automatic weapons in their defense. However, terrorists attacking a nuclear power plant could be armed with automatic weapons or other advanced weapons. NRC officials believe that a terrorist attacking a nuclear power plant could obtain and use any weapon that can be purchased on the black market, while guards generally have to rely on semiautomatic pistols, rifles, or shotguns. As a result, guards at nuclear power plants could be at a great disadvantage in terms of firepower, if attacked.

According to NRC officials, the use of fully automatic weapons would provide an important option to plants as they make security decisions about a number of factors, such as the number of plant guards, the positioning of guards at the facilities, and the quality and capabilities of surveillance equipment. According to these officials, plants will have more options in developing the appropriate combination of security elements if guards have the authority to carry automatic weapons. NRC recognizes, however, that some plant sites face special conditions under which fully automatic weapons might not be beneficial or practicable.

[12]Automatic weapons manufactured before 1986, prior to the Firearms Owners' Protection Act (18 U.S.C. 921 et. seq.) are regulated by the National Firearms Act (26 U.S.C. 5801 et. seq.), which allows civilian ownership provided certain requirements are met. States may further restrict ownership of automatic weapons.

Commercial nuclear power plants also face security challenges because of the absence of nationwide legal authority and clear guidance on when and how guards can use deadly force in defending these plants. According to NRC's regulations,[13] a guard should use deadly force in protecting nuclear power reactors against sabotage when the guard has a reasonable belief that such force is necessary for self-defense or the defense of others. However, in general, state laws govern the use of deadly force by private sector persons, and these laws vary from state to state. For example, under New Hampshire statutes, guards may not use deadly force if they can safely retreat from the encounter.[14] In contrast, Texas statutes allow guards to use deadly force in defense of private land or property, which includes nuclear power plants, without retreating, if such action is necessary to protect against another's use of unlawful force.[15] In still other states, such as Virginia and Michigan, no state statutes specifically address the issue, and the courts decide whether deadly force was appropriate in a given situation.

NRC officials believe that guards—concerned about their right to act—might second-guess, hesitate, delay, or fail to act appropriately against an attacker, thereby increasing the risk of a successful attack on the nation's nuclear power plants. During OSRE exercises, NRC officials presented guards with various scenarios that could involve the use of deadly force. In 7 of the 80 OSRE reports we reviewed (about 9 percent) NRC found that the guards did not understand or did not properly apply its guidance on the use of deadly force.

[13] 10 C.F.R. 73.55(h)(5).

[14] N.H. Rev. Stat. 627.4.

[15] TX Pen. Code, Sections 9.41-9.43.

Finally, guards at nuclear power plants do not have nationwide legal authority and clear guidance on when and how to arrest and/or detain intruders at the nation's plants. NRC officials believe that there is a question about whether federal authority can be directly granted to private security guards who are not deputized. State laws governing this authority vary. For example, in South Carolina, private security guards' authority to arrest and/or detain intruders on plant property is similar to local law enforcement officials' authority.[16] However, in most states, these guards have only the arrest authority afforded every U.S. citizen.[17]

To enable nuclear power plants to better defend against attacks, NRC has sought federal legislation that would authorize the use of deadly force to protect the plants. Legislation has not been enacted but is currently pending on arrest and detain authority.

Conclusions

NRC has taken several actions to respond to the heightened risk of attack following the September 11, 2001, terrorist attacks and, in April 2003, issued a new design basis threat that the commercial nuclear power plants must be prepared to defend against. However, NRC's past methods for ensuring that plants are taking all of the appropriate defensive measures—the annual security inspections and the force-on-force exercises—had significant weaknesses. As a result, NRC's oversight of these plants may not have provided the information necessary for NRC to ensure that the power plants were adequately defended.

In particular, NRC's past use of non-cited violations for security problems that appear to be serious is detrimental to ensuring the plants' security because NRC did not require follow-up to ensure that a non-cited violation was corrected. Lack of follow-up reduces the likelihood that needed improvements will be made. Moreover, NRC may have overstated security levels when it provided a "meeting security objectives" rating to some plants having non-cited violations that appear to have serious security implications. NRC could not have known whether some non-cited

[16]S.C. Code Section 40-18-110.

[17]Citizen's arrest authority evolved from old English law. Some states have statues specifying and clarifying citizen's arrest authority, and others rely on common law citizen's arrest authority. Generally, under common law, a private citizen may arrest another when there is probable cause to believe that the other person is committing or has committed a felony in the citizen's presence.

violations, such as guards found asleep on duty or failure to physically search for metal detected by scanners, were vulnerabilities that could have been exploited. However, accepting such vulnerabilities post-September 11, 2001, opens the power plants to undue risk. Furthermore, NRC may be missing opportunities to better oversee and improve security at the plants because it does not routinely collect, analyze, and disseminate information on security enhancements, problems, and solutions among the plants and within the agency. Such a mechanism may help other plants to improve their security.

Similarly, the force-on-force exercises were not realistic enough to ensure the identification and correction of plants' security vulnerabilities. Untrained adversary teams, temporarily enhanced defenses, and rubber weapons used in past force-on-force exercises simply do not compare with simulated attack exercises using technologically advanced tools that provide realistic, real-time experience. Furthermore, NRC was not required to conduct these exercises and has done so infrequently, thereby making plants even less prepared to address an attack. In addition, in the past, exercises have not addressed the full range of the design basis threat. Finally, delays in issuing reports on the OSRE exercises may have resulted in delays in the permanent correction of known security problems.

NRC is in the process of revising both its security inspection program and its force-on-force exercise program. What these programs will consist of when they are revised is currently unknown. NRC expects its security inspection program to be restored by 2004 and will decide the future of its force-on-force program after completing its pilot program—at a date yet to be determined. Revisions of these programs provide NRC with an opportunity to use the lessons learned from the suspended programs to strengthen them and make them more relevant to the post-September 11, 2001, environment.

Until these programs are restored, NRC is relying on plants' self-assessments and the force-on-force pilot program as its mechanisms to oversee security at the nation's nuclear power plants. The self-assessments rely on the licensees to identify problems, which then prompts NRC to conduct security inspections. Since the inspection program was curtailed in 2001, the plants have not identified any serious security problems in their self-assessments. Therefore, it is critical for NRC to revise and restore promptly its annual security inspections and force-on-force exercises to fulfill its oversight responsibilities.

Recommendations for Executive Action

To strengthen NRC's security inspection program, we recommend that the NRC Commissioners

- ensure that NRC's revised security inspection program and force-on-force exercise program are restored promptly and require that NRC regional inspectors conduct follow-up visits to verify that corrective actions have been taken when security violations, including non-cited violations, have been identified;
- ensure that NRC routinely collects, analyzes, and disseminates information on security problems, solutions, and lessons learned and shares this information with all NRC regions and licensees; and
- make force-on-force exercises a required activity and strengthen them by
  - conducting the exercises more frequently at each plant;
  - using laser equipment to ensure accurate accounts of shots fired;
  - requiring the exercises to make use of the full terrorist capabilities stated in the design basis threat, including the use of an adversary force that has been trained in terrorist tactics;
  - continuing the practice, begun in 2000, of prohibiting licensees from temporarily increasing the number of guards defending the plant and enhancing plant defenses for force-on-force exercises, or requiring that any temporary security enhancements be officially incorporated into the licensees' security plans; and
  - enforcing NRC's requirement that force-on-force exercise reports be issued within 30 to 45 days after the end of the exercise to ensure prompt correction of the problems noted.

Agency Comments and Our Evaluation

We provided a draft of this report to NRC for its review and comment. NRC stated that our report did not provide a balanced or useful perspective of its role in ensuring security at commercial nuclear power plants. NRC believed that our report was "of a historical nature," focusing on NRC's oversight of power plants before September 11, 2001, and that our report failed to reflect the changes NRC has made to its program since September

11. Furthermore, NRC commented that our characterization of non-cited violations as minimizing the significance of security problems is a serious misrepresentation. NRC said that the "anecdotal" issues noted in the draft report were "relatively minor issues" and that it treated them appropriately.

We agree that NRC has taken numerous and appropriate actions since September 11, 2001, and that additional security procedures have been, and are being, put in place to increase power plant operators' attention to enhancing security. Our draft report had discussed many of these actions, and we have added additional language to the report to more fully reflect these actions. We note that most of these actions were advisories or requirements for the licensee to enhance plant physical security and did not relate to NRC's oversight activities. With respect to NRC oversight of security at the nuclear power plants, NRC has suspended the two primary elements of its oversight program, the security inspection program and the OSRE exercises and has not yet resumed them. NRC's oversight actions since September 11 have been interim in nature; it has conducted ad hoc inspections and some force-on-force exercises as part of a pilot program. NRC said that it plans to reinstitute the security inspection and the force-on-force exercise programs in the future, but it does not now know what the revised programs will consist of. As a result, we remain convinced that it was appropriate to examine NRC's security oversight program before September 11. In the absence of any formal post-September 11 oversight program, this was the only way to systematically assess the strengths and weaknesses of NRC's oversight. Our recommendations are directed at strengthening the oversight programs and making NRC's oversight more relevant to the post-September 11 environment.

In that regard, while the NRC comments reference numerous efforts and enhancements, we note that, with one exception, these actions were designed to enhance power plant security and not to improve or enhance NRC's oversight program, which is the subject of this report. The one exception is NRC's force-on-force evaluation program, a major element in NRC's oversight program. In its comments, NRC stated that we failed to adequately reflect NRC's enhanced force-on-force evaluation program, including the increased frequency and greater degree of realism of the exercises. We disagree. NRC has not yet instituted a new force-on-force program, and our report reflects NRC's current force-on-force efforts. NRC suspended its old OSRE program after September 11, 2001, and is currently conducting pilot force-on-force exercises, which we describe in this report. NRC has not determined when a permanent program will be instituted or

what it will consist of when it is reinstituted. NRC plans to use the results of the pilot exercises to help formulate a new, permanent program.

We also disagree that the "anecdotal" issues cited in the draft report were "relatively minor issues" and do not believe that the continued extensive use of non-cited violations will achieve the best oversight. Sleeping guards, unauthorized access to protected areas, disabled alarms in the vital area, and failure to inspect visitors who set off alarms on metal detectors are all serious security problems that warrant NRC attention and oversight. NRC's belief that it should rely on the licensees to self-identify and correct these types of problems is troubling. Instead of discounting problems that are, on their face, quite worrisome, NRC should aggressively determine the root cause of the problems, formulate corrective actions, and follow up to ensure that the approved corrective actions have been implemented and that the implemented actions have corrected the problems. The use of non-cited violations delegates these activities and responsibilities to the licensees. NRC believes that such delegation is appropriate and that the use of non-cited violations contributes to an environment in which the licensee self-identifies and corrects problems, a behavior that NRC said it encourages. However, in the cases we cited, the delegation of responsibility for identifying and correcting security problems was not effective because all were security problems that the licensee failed to identify, but instead were found by NRC security inspectors.

Finally, NRC stated that its process requires it to review a sampling of the licensees' corrective actions to ensure that the licensees are implementing the corrective actions. NRC failed to note, however, that the requirement cited is part of the baseline security inspection program that was suspended after September 11, 2001, and that has not been reinstated. In addition, when NRC was conducting baseline security inspections, the program required corrective action checks only every 2 years, and the sample selected for checks included all corrective actions—safety and emergency preparedness, as well as security. As a result, NRC had no assurance that any security corrective actions would be selected for follow-up. Licensees should be involved in identifying and correcting problems. However, we believe that by delegating these functions to the licensee, NRC is abandoning its oversight responsibilities and, as a result, cannot guarantee that problems are identified and corrected.

NRC did not comment on our recommendations for reinstituting and improving its baseline inspection and force-on-force exercise programs. Nevertheless, we hope that NRC decides to implement our

recommendations as it fulfills its 31 U.S.C. 720 requirement to submit a written statement of the actions taken on our recommendations. This statement is to be submitted to the Senate Committee on Governmental Affairs and the House Committee on Government Reform not later than 60 days after the date of this report's release, and to the Senate and House Committees on Appropriations with the agency's first request for appropriations made more than 60 days after that same date.

In addition to its overall comments and observations (see app. III), NRC provided a number of technical comments and clarifications, which we incorporated in this report as appropriate.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after the date of this letter. At that time, we will send copies of the report to interested congressional committees, the Chairman of the Nuclear Regulatory Commission, and the Director of the Office of Management and Budget. We will make copies available to others on request. In addition, this report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions about this report, please call me at (202) 512-3841 or contact me at Wellsj@gao.gov. Key contributors to this report are listed in appendix IV.

Jim Wells

Jim Wells
Director, Natural Resources and Environment

Scope And Methodology

Our objectives were to review (1) the effectiveness of the Nuclear Regulatory Commission's (NRC) inspection program to oversee security at commercial nuclear power plants and (2) legal challenges currently affecting physical security at the power plants.

To meet these objectives, we visited NRC's Headquarters in Rockville, Maryland, and Region I in King of Prussia, Pennsylvania; obtained NRC advisories, orders, regulations, Operational Safeguards Response Evaluation (OSRE) reports, and annual security inspection reports; and interviewed officials who were knowledgeable about NRC's physical security requirements for nuclear power plants. We also visited the Limerick, Oyster Creek, and Calvert Cliffs power plants; obtained licensee documents and requirements regarding their security procedures; and interviewed licensee officials who were knowledgeable about the facilities' security plans, procedures, and NRC's nuclear power plant physical security regulations. During our visits, we observed the security measures that were put in place to reflect NRC's advisories and orders since the terrorist attacks of September 11, 2001.

To determine the extent of NRC's oversight of nuclear power plant security, we held discussions with NRC Region I security inspectors and officials in NRC's Office of Nuclear Security and Incident Response, Office of General Counsel, and Office of the Executive Director for Operations. We also held discussions with licensee officials at the Limerick, Oyster Creek, and Calvert Cliffs power plants on their security procedures and mechanisms and on their interaction with NRC security inspectors. In addition, we collected information on nuclear security from all NRC regional security offices.

To determine how NRC assesses the quality of daily security procedures and mechanisms against the licensees' security plans, we obtained and reviewed all 49 NRC inspection reports that contained a finding that was judged to be of moderate significance or higher. We also had discussions with officials in NRC's Office of Nuclear Security and Incident Response regarding the methods for conducting and reporting annual inspections and in NRC's Office of Enforcement regarding how security violations are administered.

To determine how NRC tests licensees against the design basis threat, we interviewed NRC officials to understand both the process for OSRE exercises and report writing and the follow-up procedures for any concerns found during an OSRE exercise. We also examined all OSRE reports from

each NRC licensee. We designed a data collection instrument in order to organize specific elements that were extracted from 80 OSRE reports. Two GAO analysts followed procedures to ensure the completeness of all data collection instrument entries. The data collection instrument data were entered into a spreadsheet file for analysis. To detect potential coding and keying errors, the accuracy of the data entered into the spreadsheet file was verified. We also held discussions with Department of Energy officials to (1) determine how they conduct force-on-force exercises at the department's nuclear facilities and (2) determine if there are any promising practices that might be applied to NRC's OSRE program.

To determine NRC's views on federal and state laws and on NRC institutional policies (i.e., regarding the use of automatic weapons, the authority to use deadly force, and the authority to arrest and detain) that could impact a licensee's ability to adequately secure commercial nuclear power plants, we discussed these issues with officials from NRC's Office of Nuclear Security and Incident Response and Office of General Counsel. Additionally, we discussed these same issues with industry officials who were specifically knowledgeable about these areas. We examined existing federal and state laws, and we also examined federal and state bills that have been proposed or are pending legislative passage.

Appendix II

U.S. Commercial Nuclear Power Plants That Are Licensed to Operate

Power plant	City	State	NRC region
Arkansas Nuclear 1	Russellville	AR	4
Arkansas Nuclear 2	Russellville	AR	4
Beaver Valley 1	McCandless	PA	1
Beaver Valley 2	McCandless	PA	1
Braidwood 1	Joilet	IL	3
Braidwood 2	Joilet	IL	3
Browns Ferry 1	Decatur	AL	2
Browns Ferry 2	Decatur	AL	2
Browns Ferry 3	Decatur	AL	2
Brunswick 1	Southport	NC	2
Brunswick 2	Southport	NC	2
Bryon 1	Rockford	IL	3
Bryon 2	Rockford	IL	3
Callaway	Fulton	MO	4
Calvert Cliffs 1	Annapolis	MD	1
Calvert Cliffs 2	Annapolis	MD	1
Catawba 1	Rock Hill	SC	2
Catawba 2	Rock Hill	SC	2
Clinton	Clinton	IL	3
Columbia Generating Station	Richland	WA	4
Comanche Peak 1	Glen Rose	TX	4
Comanche Peak 2	Glen Rose	TX	4
Cooper	Nebraska City	NE	4
Crystal River 3	Crystal River	FL	2
D C Cook 1	Benton Harbor	MI	3
D C Cook 2	Benton Harbor	MI	3
Davis-Besse	Toledo	OH	3
Diablo Canyon 1	San Luis Obispo	CA	4
Diablo Canyon 2	San Luis Obispo	CA	4
Dresden 2	Morris	IL	3
Dresden 3	Morris	IL	3
Duane Arnold	Cedar Rapids	IA	3
Edwin I. Hatch 1	Baxley	GA	2
Edwin I. Hatch 2	Baxley	GA	2
Fermi 2	Toledo	MI	3

(Continued From Previous Page)

Power plant	City	State	NRC region
Fort Calhoun	Omaha	NE	4
Ginna	Rochester	NY	1
Grand Gulf 1	Vicksburg	MS	4
H.B. Robinson 2	Florence	SC	2
Hope Creek 1	Lower Alloways Creek	NJ	1
Indian Point 2	New York	NY	1
Indian Point 3	New York	NY	1
James A. FitzPatrick	Oswego	NY	1
Joseph M. Farley 1	Dothan	AL	2
Joseph M. Farley 2	Dothan	AL	2
Kewaunee	Green Bay	WI	3
La Salle 1	Ottawa	IL	3
La Salle 2	Ottawa	IL	3
Limerick 1	Philadelphia	PA	1
Limerick 2	Philadelphia	PA	1
McGuire 1	Charlotte	NC	2
McGuire 2	Charlotte	NC	2
Millstone 2	New London	CT	1
Millstone 3	New London	CT	1
Monticello	Minneapolis	MN	3
Nine Mile Point 1	Oswego	NY	1
Nine Mile Point 2	Oswego	NY	1
North Anna 1	Richmond	VA	2
North Anna 2	Richmond	VA	2
Oconee 1	Greenville	SC	2
Oconee 2	Greenville	SC	2
Oconee 3	Greenville	SC	2
Oyster Creek	Toms River	NJ	1
Palisades	South Haven	MI	3
Palo Verde 1	Phoenix	AZ	4
Palo Verde 2	Phoenix	AZ	4
Palo Verde 3	Phoenix	AZ	4
Peach Bottom 2	Lancaster	PA	1
Peach Bottom 3	Lancaster	PA	1
Perry 1	Painesville	OH	3
Pilgrim 1	Plymouth	MA	1
Point Beach 1	Manitowoc	WI	3

(Continued From Previous Page)

Power plant	City	State	NRC region
Point Beach 2	Manitowoc	WI	3
Prairie Island 1	Minneapolis	MN	3
Prairie Island 2	Minneapolis	MN	3
Quad Cities 1	Moline	IL	3
Quad Cities 2	Moline	IL	3
River Bend 1	Baton Rouge	LA	4
Salem 1	Lower Alloways Creek	NJ	1
Salem 2	Lower Alloways Creek	NJ	1
San Onofre 2	San Clemente	CA	4
San Onofre 3	San Clemente	CA	4
Seabrook 1	Portsmouth	NH	1
Seqouyah 1	Chattanooga	TN	2
Seqouyah 2	Chattanooga	TN	2
Shearon Harris 1	Raleigh	NC	2
South Texas Project 1	Bay City	TX	4
South Texas Project 2	Bay City	TX	4
St. Lucie 1	Ft. Pierce	FL	2
St. Lucie 2	Ft. Pierce	FL	2
Summer	Columbia	SC	2
Surry 1	Newport News	VA	2
Surry 2	Newport News	VA	2
Susquehanna 1	Berwick	PA	1
Susquehanna 2	Berwick	PA	1
Three Mile Island 1	Harrisburg	PA	1
Turkey Point 3	Miami	FL	2
Turkey Point 4	Miami	FL	2
Vermont Yankee	Battleboro	VT	1
Vogtle 1	Augusta	GA	2
Vogtle 2	Augusta	GA	2
Waterford 3	New Orleans	LA	4
Watts Bar 1	Spring City	TN	2
Wolf Creek 1	Burlington	KS	4

Source: NRC.

Appendix III

Comments from the Nuclear Regulatory Commission

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

CHAIRMAN

August 7, 2003

Mr. James Wells, Director
Natural Resources and Environment
United States General Accounting Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Wells:

On behalf of the Nuclear Regulatory Commission (NRC), I am responding to your July 15, 2003, letter requesting the NRC's review of the draft report (GAO-03-752) entitled "Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to be Strengthened." I appreciate the opportunity to provide comments to the General Accounting Office (GAO). I, and my fellow Commissioners, are concerned that this draft report does not provide an appropriately balanced or very useful perspective of the NRC's role in assuring nuclear power plant security.

The report, while it accurately describes some of the legal challenges that currently exist, fails to fully recognize the significant effort the NRC has made in the post-September 11, 2001, environment to strengthen what was already a very robust security program. The staff is preparing more detailed comments to address issues of correctness, currentness, and clarity. These comments will follow in a subsequent letter from the agency's Executive Director for Operations (EDO). However, I have several observations of note.

First, this report is of a historical nature, focusing almost exclusively on NRC's oversight of nuclear power plants prior to September 11, 2001. It thus fails to adequately reflect significant changes we have made to our program to meet the current challenges. These include:

- the extensive effort and direct oversight (substantially more than prior to 9/11) the NRC has provided at every nuclear plant while it revamps the security inspection program;
- a greatly enhanced personnel access authorization program through the application of new requirements and improved processes;
- enhanced training, qualification, and fitness-for-duty requirements for security forces;
- close interaction with the intelligence community that resulted in a revision to the Design Basis Threat which will require licensees to upgrade their security plans and defensive capabilities;
- an enhanced force-on-force evaluation program including increased frequency of drills and exercises and a greater degree of realism;

-2-

- significant outreach efforts to Federal, State and local organizations to improve the integrated response to an actual event; and

- extensive interactions with the Department of Homeland Security and the Homeland Security Council on security at commercial nuclear power plants. These efforts include protection of the national infrastructure as well as vulnerability assessments and mitigation strategies.

Second, the report's emphasis on non-cited violations as somehow "minimizing" the significance of security problems is a serious misrepresentation. The individual anecdotal issues noted in the report were appropriately treated within the NRC's enforcement process. NRC's regulatory process necessarily relies on licensees taking corrective actions. The use of non-cited violations contributes to an environment that fosters licensee self-identification and correction of problems, an important organizational behavior the NRC encourages. The NRC's process requires that a sampling of those corrective actions are reviewed during subsequent inspections to assure that the process is being properly implemented.

I note that the key issues you raised are relatively minor issues and had already been identified by the NRC before your review was initiated. Corrective actions for these issues either have been completed or are nearly complete.

Again, I appreciate the opportunity to comment on this draft report. As I noted earlier, the EDO will be responding soon with more detailed comments.

Sincerely,

Nils J. Diaz

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United States General Accounting Office

GAO

Report to the Honorable Edward J. Markey, House of Representatives

October 2003

NUCLEAR REGULATION

NRC Needs More Effective Analysis to Ensure Accumulation of Funds to Decommission Nuclear Power Plants

GAO-04-32

GAO
Accountability·Integrity·Reliability

Highlights

Highlights of GAO-04-32, a report to the Honorable Edward J. Markey, House of Representatives

Why GAO Did This Study

Following the shutdown of a nuclear power plant a significant radioactive waste hazard remains until the waste is removed and the plant site decommissioned. In 1999, GAO reported that the combined value of the owners' decommissioning funds was insufficient to ensure enough funds would be available for decommissioning. GAO was asked to update its 1999 report and to evaluate the Nuclear Regulatory Commission's (NRC) analysis of the owners' funds and its process for acting on reports that show insufficient funds.

What GAO Recommends

NRC should (1) develop an effective method for determining whether owners are accumulating decommissioning funds at sufficient rates and (2) establish criteria for taking action when it is determined that an owner is not accumulating sufficient funds. NRC disagreed with these recommendations suggesting that its method is effective and that it is better to deal with unacceptable levels of financial assurance on a case-by-case basis. GAO continues to believe that limitations in NRC's method reduce its effectiveness and without criteria, NRC might not be able to ensure owners are accumulating decommissioning funds at sufficient rates.

www.gao.gov/cgi-bin/getrpt?GAO-04-32.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells, at (202) 512-6877 or WellsJ@gao.gov.

October 2003

NUCLEAR REGULATION

NRC Needs More Effective Analysis to Ensure Accumulation of Funds to Decommission Nuclear Power Plants

What GAO Found

Although the collective status of the owners' decommissioning fund accounts has improved considerably since GAO's last report, some individual owners are not on track to accumulate sufficient funds for decommissioning. Based on our analysis and most likely economic assumptions, the combined value of the nuclear power plant owners' decommissioning fund accounts in 2000—about \$26.9 billion—was about 47 percent greater than needed at that point to ensure that sufficient funds will be available to cover the approximately \$33 billion in estimated decommissioning costs when the plants are permanently shutdown. This value contrasts with GAO's prior finding that 1997 account balances were collectively 3 percent below what was needed. However, overall industry results can be misleading. Because funds are generally not transferable from funds that have more than sufficient reserves to those with insufficient reserves, each individual owner must ensure that enough funds are available for decommissioning its particular plants. We found that 33 owners with ownership interests in a total of 42 plants had accumulated fewer funds than needed through 2000 to be on track to pay for eventual decommissioning. In addition, 20 owners with ownership interests in a total of 31 plants recently contributed less to their trust funds than we estimate they needed to put them on track to meet their decommissioning obligations.

NRC's analysis of the owners' 2001 biennial reports was not effective in identifying owners that might not be accumulating sufficient funds to cover their eventual decommissioning costs. In reviewing the 2001 reports, NRC reported that all owners appeared to be on track to have sufficient funds for decommissioning. In reaching this conclusion, NRC relied on the owners' future plans for fully funding their decommissioning obligations. However, based on the owners' recent actual contributions, and using a different method, GAO found that several owners could be at risk of not meeting their financial obligations for decommissioning when these plants stop operating. In addition, for plants with more than one owner, NRC did not separately assess the status of each co-owner's trust funds against each co-owner's contractual obligation to fund decommissioning. Instead, NRC assessed whether the combined value of the trust funds for the plant as a whole was reasonable. Such an assessment for determining whether owners are accumulating sufficient funds can produce misleading results because owners with more than sufficient funds can appear to balance out owners with less than sufficient funds even, though funds are generally not transferable among owners. Moreover, NRC has not established criteria for taking action if it determines that an owner is not accumulating sufficient funds.

Contents

Abbreviations

FERC	Federal Energy Regulatory Commission
GDP	Gross Domestic Product
NRC	Nuclear Regulatory Commission
SAFSTOR	Safe Storage

GAO
Accountability * Integrity * Reliability

United States General Accounting Office
Washington, D.C. 20548

October 30, 2003

The Honorable Edward J. Markey
House of Representatives

Dear Mr. Markey:

Following the retirement of a nuclear power plant and removal of the plant's spent or used fuel, a significant radioactive waste hazard remains until the waste is removed and disposed of, and the plant site decommissioned.[1] Decommissioning of existing plants is expected to cost nuclear power plant owners about $33 billion dollars.[2] The Nuclear Regulatory Commission (NRC), which licenses nuclear power plants, requires plant owners to submit biennial reports on decommissioning funding that, among other things, provide financial assurance that enough funding will be available when the power plants are retired.

In 1999, we reported that the combined value of the owners' decommissioning trust fund accounts (as of the end of 1997) was 3 percent less than needed to ensure that enough funds would be available when the plants are retired.[3] In addition, we found that NRC had not established criteria for responding to unacceptable levels of financial assurance. In December 2001, we reported that transfers of plant licenses among companies stemming from economic deregulation and the restructuring of the electricity industry had, in many cases, increased assurances that new plant owners would have sufficient decommissioning funds when their plants are retired.[4] Nevertheless, in some instances, NRC's evaluation of the adequacy of funding arrangements was not rigorous enough to ensure that decommissioning funds would be adequate.

[1]Retirement means the permanent cessation of a plant's operation.

[2]Costs in 2000 present value dollars and are for decommissioning the plant site only and exclude costs for cleaning up nonradiological hazards and storing spent fuel.

[3]U.S. General Accounting Office, *Nuclear Regulation: Better Oversight Needed to Ensure Accumulation of Funds to Decommission Nuclear Power Plants*, GAO/RCED-99-75 (Washington, D.C.: May 3, 1999).

[4]U.S. General Accounting Office, *Nuclear Regulation: NRC's Assurances of Decommissioning Funding during Utility Restructuring Could Be Improved*, GAO-02-48 (Washington, D.C.: Dec. 3, 2001).

In this context, you asked us to update our earlier findings on the adequacy of owners' decommissioning funds. Specifically, this report (1) assesses the extent to which nuclear plant owners are accumulating funds at sufficient rates to pay decommissioning costs when their plants' licenses expire and (2) evaluates NRC's analysis of the owners' 2001 biennial reports and its process for acting on reports that show unacceptable levels of financial assurance.

As part of our review, we collected data from the 2001 biennial reports on estimated decommissioning costs and actual decommissioning trust fund balances, generally as of December 31, 2000, for 122 nuclear power plants licensed by NRC. In addition, we surveyed the owners of the plants to determine how the trust fund balances were invested in 2000 and to identify the annual amounts that the owners had contributed to the trust funds in recent years. Eighty-two percent of the owners responded to our survey.[5] Using an approach similar to that used for our 1999 report,[6] we analyzed both the combined efforts of all owners to accumulate funds to decommission all of the nuclear plants and each individual owner's efforts to accumulate funds for decommissioning each of its plants. For our analysis, we estimated the most likely future values of key assumptions, such as decommissioning costs, earnings on the decommissioning funds' assets, and the operating life of each plant. To address the inherent uncertainty associated with forecasting outcomes many years into the future, we also analyzed the effect of using pessimistic and optimistic values for these key assumptions. To evaluate NRC's analysis of the biennial reports and its process for acting on reports that have not satisfied decommissioning funding assurance requirements, we reviewed NRC's guidelines and policies for analyzing these reports and interviewed NRC's officials about how they conducted their analysis. Appendix I provides more detail on the scope and methodology of our review.

Results in Brief

Although the collective status of the owners' decommissioning fund accounts has improved since our last report, some individual owners are not on track to accumulate sufficient funds for decommissioning. Using

[5]We administered the survey to 110 owners. Since then, the ownership of some plants has changed and as a result, the total number of owners has declined. Our analysis assesses 222 trust funds held by 99 owners.

[6]GAO/RCED-99-75.

our most likely economic assumptions, the combined value of the nuclear plant owners' trust funds in 2000—about $26.9 billion—was about 47 percent greater than needed at that point to ensure that sufficient funds will be available to cover the approximately $33 billion in estimated decommissioning costs when the plants are retired. This value contrasts with account balances that collectively were 3 percent below what was needed by the end of 1997. Overall industry results can be misleading, however. Because NRC does not allow owners to transfer funds from a trust fund with sufficient reserves to one without sufficient reserves, each individual owner must ensure that enough funds are available for decommissioning its particular plants. We found that 33 owners of all or parts of 42 different plants had accumulated less funds than we estimated they needed to have through 2000 to be on track to pay for eventual decommissioning. Under our most likely assumptions, these owners will have to increase the rates at which they accumulate funds to meet their future decommissioning obligations. Of the 33 owners, 26 provided contributions information for our survey. Of these 26 owners, only 8 appeared to be making up their shortfalls with recent increases in contributions to their trust funds.

NRC's analysis of the owners' 2001 biennial reports was not effective in identifying owners that might not be accumulating sufficient funds to cover their eventual decommissioning costs. In reviewing the 2001 reports, NRC reported that all owners appeared to be on track to have sufficient funds for decommissioning. In reaching this conclusion, NRC relied on the owners' future plans for fully funding their decommissioning obligations. However, based on the actual contributions the owners recently made to their trust funds, we found that several owners could risk not meeting their financial obligations for decommissioning when these plants are retired. In addition, for the plants with more than one owner, NRC did not separately assess the status of each co-owner's trust funds against the co-owner's contractual obligation to fund decommissioning. Instead, NRC assessed whether the combined value of the trust funds for each plant as a whole was reasonable. Such an assessment for determining whether owners are accumulating sufficient funds can produce misleading results because owners with more than sufficient funds can appear to balance out owners with less than sufficient funds, even though funds are generally not transferable among owners. Furthermore, NRC has not established criteria for responding to any unacceptable levels of financial assurance. Accordingly, we are recommending that NRC develop and use an effective method for determining whether owners are accumulating funds at

sufficient rates and establish criteria for responding to unacceptable levels of financial assurance.

Background

NRC's primary mission is to protect the public health and safety, and the environment, from the effects of radiation from nuclear plants, materials, and waste facilities. Because decommissioning a nuclear power plant is a safety issue, NRC has authority to ensure that owners are financially qualified to decommission these plants.

Of the 125 nuclear power plants that have been licensed to operate in the United States since 1959, 3 have been completely decommissioned. Of the remaining 122 plants, 104 currently have operating licenses (although 1 has not operated since 1985), 11 plants are in safe storage (SAFSTOR) awaiting active decommissioning,[7] and 7 plants are being decommissioned. At the time of our analysis, 43 plants were co-owned by different owners.

NRC regulations limit commercial nuclear power plant licenses to an initial 40 years of operation but also permit such licenses to be renewed for additional 20 years if NRC determines that the plant can be operated safely over the extended period. NRC has approved license renewals for 16 plants (as of August 20, 2003).

In 1988, NRC began requiring owners to (1) certify that sufficient financial resources would be available when needed to decommission their nuclear power plants and (2) require them to make specific financial provisions for decommissioning.[8] In 1998, NRC revised its rules to require plant owners to report to the NRC by March 31, 1999, and at least once every 2 years thereafter on the status of decommissioning funding for each plant or proportional share of a plant they own.[9] Under NRC requirements, the

[7]SAFSTOR involves placing the stabilized and defueled facility in storage for a time followed by final decontamination and dismantlement, and license termination.

[8]NRC licenses include all co-owners as co-licensees; in general, one owner is authorized to operate the facility while the others are authorized only to have an ownership interest. Co-owners generally divide costs and output from their power plants by using a contractually defined pro rata share standard.

[9]U.S. Nuclear Regulatory Commission, *Financial Assurance Requirements* (Sept. 22, 1998), 63 Fed. Reg. 50465.

owners can choose from one or more methods, including the following, to provide decommissioning financial assurance:

- prepayment of cash or liquid assets into an account segregated from the owner's assets and outside the owner's administrative control;
- establishment of an external sinking fund maintained through periodic deposit of funds into an account segregated from the owner's assets and outside the owner's administrative control;
- use of a surety method (i.e., surety bond, letter of credit, or line of credit payable to a decommissioning trust account), insurance, or other method that guarantees that decommissioning costs will be paid; and
- for federal licensees, a statement of intent that decommissioning funds will be supplied when necessary.

In September 1998, NRC amended its regulations to restrict the use of the external sinking fund method in deregulated electricity markets. Prior to this time, essentially all nuclear plant owners chose this method for accumulating decommissioning funds. However, under the amended regulations, owners may rely on periodic deposits only to the extent that those deposits are guaranteed through regulated rates charged to consumers.

In conjunction with its amended regulations, NRC issued internal guidance, describing the process for reviewing the adequacy of a prospective owner's financial qualifications to safely operate and maintain its plant(s) and the owner's proposed method(s) for ensuring the availability of funds to eventually decommission the plant(s).[10] The guidance outlines a method for evaluating the owner's financial plans for fully funding decommissioning costs. In addition, the guidance states that, except under certain conditions, the NRC reviewer should, when plants have multiple owners, separately evaluate each co-owner's funding schedule for meeting its share of the plant's decommissioning costs.[11]

[10]U.S. Nuclear Regulatory Commission, *Standard Review Plan on Power Reactor Licensee Financial Qualifications and Decommissioning Funding Assurance*, NUREG 1577, Rev. 1, March 1999.

[11]Under NRC's guidance, co-owners trust funds can be collectively evaluated when the lead licensee agrees to coordinate funding documentation and reporting for all the co-owners.

Despite Industry-wide Improvement, Some Owners of Nuclear Power Plants Are Not Accumulating Sufficient Decommissioning Funds

Using our most likely economic assumptions, the combined value of the nuclear power plant owners' decommissioning trust funds was about 47 percent higher at the end of 2000 than necessary to ensure accumulation of sufficient funds by the time the plants' licenses expire. This situation contrasts favorably with the findings in our 1999 report, which indicated that the industry was about 3 percent below where it needed to be at the end of 1997 to ensure that enough funds would be available. However, because owners are not allowed to transfer funds from a trust fund with sufficient reserves to one without sufficient reserves, overall industry sufficiency can be misleading. When we individually analyzed the owners' trust funds, we found that 33 owners for several different plants had not accumulated funds at a rate that would be sufficient for eventual decommissioning.

Collectively the Nuclear Power Industry Is on Pace to Accumulate More Than Sufficient Funds for Decommissioning

Through 2000, the owners of 122 operating and retired nuclear power plants collectively had accumulated about 47 percent more funds than would have been sufficient for eventually decommissioning, using our most likely economic assumptions. Specifically, the owners had accumulated about $26.9 billion—about $8.6 billion more than we estimate they needed at that point to ensure sufficient funds. This situation contrasts with the findings in our 1999 report, which indicated that the industry had accumulated about 3 percent less than the amount we estimated it should have accumulated by the end of 1997.

Using alternative economic assumptions changes these results. For example, under higher decommissioning costs and other more pessimistic assumptions, the analysis shows that the combined value of the owners' accounts would be only about 0.2 percent above the amount we estimate the industry should have collected by the end of 2000. (See app. II for our results using more optimistic assumptions.)

The collective improvement in the status of the owners' trust funds (under most likely assumptions) since our last report is due to three main factors. First, all or parts of the estimated decommissioning costs were prepaid for 15 plants when they were sold to new owners. For example, the seller prepaid $396 million when the Pilgrim 1 nuclear plant was sold in 1998 for the plant's scheduled decommissioning in 2012. Second, for 16 other plants, NRC approved 20-year license renewals, which will provide additional time for the owners to make contributions and for the earnings to accumulate on the decommissioning fund balances. Third, owners earned a higher rate of return on their trust fund accounts than we projected in our 1999 report. For example, the average return on the trust funds of owners who responded to our survey was about 8.5 percent[12] (after-tax nominal return) per year, from 1998 through 2000, instead of the approximately 6.25 percent per year we had assumed. The higher return was a result of the stronger than expected performance of financial markets in the late 1990s.[13] Since that time, however, the economy has slowed and financial markets—equities in particular—have generally performed poorly.

Several Owners Are Not Accumulating Sufficient Funds for Decommissioning Their Plants

In contrast to the encouraging industry-wide results, when we analyzed the owners' trust fund accounts individually, we found that several owners were not accumulating funds at rates that would be sufficient to pay for decommissioning if continued until their plants are retired. Each owner has a trust fund for each plant that it owns in whole or in part. For example, the Exelon Generation Company owns all or part of 20 different plants. For this analysis, we assessed the status of 222 trust funds for 122 plants owned in whole or part by 99 owners. As shown in table 1, using our most likely assumptions, 33 owners of all or parts of 42 different plants (50 trust funds) had accumulated less funds than needed through 2000 to be on track to pay for eventual decommissioning (see app. II for details).[14] Thirteen of these

[12]Based on 72 owners who provided after-tax rates of return for 1998, 1999, and 2000. These owners' trust funds accounted for about 71 percent of the total trust funds in 2000.

[13]For 2000 (the only year for which we have data on fund allocations), on average, owners allocated their funds rather evenly between equities and fixed income assets (see app. I for details). Investment plans such as pension funds that invested more heavily in equities may have earned a greater overall return during this period.

[14]Some owners whom we estimate are below the benchmark have a parent company guarantee or other method to support financial assurance obligations. However, we did not evaluate the adequacy of these provisions. See app. II, table 4.

plants were shut down before sufficient funds had been accumulated for decommissioning. Although the remaining 78 owners of all or parts of 93 plants (172 trust funds) had accumulated more funds than we estimate they needed to have at the end of 2000, funds are generally not transferable from owners who have more than sufficient reserves to other owners who have insufficient reserves. Under our most likely assumptions, the owners whom we estimate to be behind will have to increase the rates at which they accumulate funds to meet their eventual decommissioning financial obligations.

For our analysis, we compared the trust fund balance that individual owners had accumulated for each plant by the end of 2000 with a "benchmark" amount of funds that we estimate they should have accumulated by that date. In setting the benchmark, we assumed that the owners would contribute increasing (but constant present-value) amounts annually to cover eventual decommissioning costs.[15] For example, at the end of 2000, an owner's decommissioning fund for a plant that had operated one-half of a 40-year license period (begun in 1980) should contain one-half of the present value of the estimated cost to decommission the owner's share of that plant in 2020. Although this benchmark is not the only way an owner could accrue enough funds to pay future decommissioning costs, it provides both a common standard for comparisons among owners and, from an equity perspective among ratepayers in different years, a financially reasonable growing current-dollar funding stream over time. Appendix I describes our methodology in more detail.

[15]Our analysis simulates that the owners will increase their yearly future funding at the assumed after-tax rate of return on the investments of the funds, and that once in the fund, these yearly contributions will grow at this same rate. See appendix I for a discussion of our methodology.

Table 1: Status of Individual Owners' Trust Fund Balances through 2000, Compared with Benchmark Trust Fund Balances, under Most Likely Assumptions[a]

Status	Trust funds	Owners	Plants currently operating	Plants shut down
Above benchmark balance	172	78	88	5
Below benchmark balance	50	33	29	13
Total	**222**	[b]	[b]	[b]

Source: GAO analysis.

[a]Most likely assumptions include 20-year license renewals that have been approved by NRC for 16 plants as of August 20, 2003.

[b]Not applicable.

The status of each owner's fund balance at the end of 2000 is not, by itself, the only indicator of whether an owner will have enough funds for decommissioning. Whether the owner will accumulate the necessary funds also depends on the rate at which the owner contributes funds over the remaining operating life of the plant; by increasing their contribution rates, owners whose trust fund balances were below the benchmark level could still accumulate the needed funds. Consequently, for the owners who provided contributions information to us, we also analyzed whether their recent contribution rates would put them on track to meet their decommissioning obligations. For this second analysis, we compared the average of the amounts contributed in 1999 and 2000 (cost-adjusted to 2000) with a benchmark amount equivalent to the average yearly present value of the amounts the owners would have to accumulate each year over the remaining life of their share of the plants to have enough decommissioning funds.

As table 2 shows, 28 owners with ownership shares in 44 different plants (50 trust funds) contributed less than the amounts we estimate they will need to meet their decommissioning obligations, under our most likely assumptions.

Table 2: Status of Individual Owners' Recent Trust Fund Contributions, Compared with Benchmark Trust Fund Contributions, under Most Likely Assumptions[a]

Status	Trust funds	Owners	Plants currently operating	Plants shut down
Above benchmark contributions	122	58	76	5
Below benchmark contributions	50	28	34	10
Total	**172[b]**	[c]	[c]	[c]

Source: GAO analysis.

[a]Most likely assumptions include 20-year license renewals that have been approved by NRC for 16 plants as of August 20, 2003.

[b]Contributions not available for 50 other trust funds.

[c]Not applicable.

We compared the owners in table 1 with those in table 2 to see whether owners who are behind in balances were making up their shortfalls with recent increases in contributions. Of the 33 owners who we estimate had less than the benchmark balances through 2000, 26 owners of all or parts of 38 plants provided contributions information. Of these owners, only 8 owners of all or parts of 9 plants appeared to be making up their shortfalls with recent increases in contributions. By contrast, 20 owners with ownership interests in 31 plants recently contributed less to their trust funds than we estimate they needed to put them on track to meet their decommissioning obligations.[16]

These results would change under alternative economic assumptions. For example, if economic conditions improve to those assumed in our optimistic scenario, of the 20 owners who were below the benchmark under most likely assumptions on both balances and contributions, 12 owners would still be below the benchmark in both categories, even under optimistic assumptions.

However, if economic conditions worsen to those in our pessimistic scenario, 34 owners who were above the benchmark under most likely assumptions on either balances or contributions would be below either of

[16]Some of these owners were also making up their shortfalls on other plants.

these benchmarks under pessimistic assumptions. (See app. II for detailed results.)

NRC's Analysis Did Not Effectively Determine Whether Each Owner Was Accumulating Sufficient Decommissioning Funds

NRC's analysis of the 2001 biennial decommissioning status reports was not effective in identifying owners that might not be accumulating funds at sufficient rates to pay for decommissioning costs when their plants are permanently shut down. Although the NRC reported in 2001 that all owners appeared to be on track to have sufficient funds for decommissioning,[17] our analysis indicated that several owners might not be able to meet financial obligations for decommissioning. NRC's analysis was not effective for two reasons. First, NRC overly relied on the owners' future funding plans, or on rate-setting authority decisions, in concluding that the owners were on track to fully fund decommissioning. However, as discussed earlier, based on actual contributions the owners had recently made to their trust funds, several owners are at risk of not accumulating enough funds to pay for decommissioning. Second, for the plants with more than one owner, NRC did not separately assess the status of each co-owner's trust funds relative to the co-owner's contractual obligation to fund a certain portion of decommissioning. Instead, NRC combined funds on a plant-wide basis and assessed whether the combined trust funds would be sufficient for decommissioning. Such an assessment method can produce misleading results because the owners with more than sufficient trust funds can appear to balance out those with insufficient trust funds. Furthermore, if NRC had identified an owner with unacceptable levels of financial assurance, it would not have had an explicit basis for acting to remedy potential funding deficiencies because it has not established criteria for responding to unacceptable levels of financial assurances.

NRC officials said that their oversight of the owners' decommissioning funds is an evolving process and that they intend to learn from their review of prior biennial reports and make changes to improve their evaluation of the 2003 biennial reports. However, they also said that any specific changes they are considering are predecisional, and final decisions have not yet been made.

[17] *Summary of Decommissioning Trust Funding Status Reports For Power Reactors*, SECY-01-0197, Nuclear Regulatory Commission, November 5, 2001.

NRC's Review Relied on Owners' Future Plans for Making Contributions

According to NRC officials, in reviewing the 2001 biennial reports, they used a "straight-line" method to establish a screening criterion for assessing whether owners were accumulating decommissioning funds at sufficient rates. Specifically, NRC compared the amount of funds accumulated through 2000 (expressed as a percentage of the total estimated cost as of 2000 to decommission the plant) to the expended plant life (expressed as a percentage of the total number of years the plant will operate). Under this method, the owner of a plant that has operated for one-half of its operating life would be expected to have accumulated at least one-half of the plant's estimated decommissioning costs (that is, it would be collecting at or above the straight-line rate). NRC found that the owners of 64 out of 104 plants currently licensed to operate were collecting at the above a straight-line rate, and that the owners of the remaining 40 plants were collecting at the less than a straight-line rate.[18]

On a plant-wide basis, NRC then reviewed the owners' "amortization" schedules for making future payments to fully fund decommissioning. The schedules, required as part of the biennial reports, consist of the remaining funds that the owners expect to collect each year over the remaining operating life of the plants. In estimating the funds to be collected, the owners may factor in the earnings expected from their trust fund investments. To account for such earnings, NRC regulations allow an owner to increase its trust fund balance by up to 2 percent per year (net of estimated cost escalation), or higher, if approved by its regulatory rate-setting authority, such as a state public utility commission. Because these owners' amortization schedules identified sufficient future funds to enable them to reach the target funding levels, NRC concluded that all licensees appear to be on track to fund decommissioning when their plants are retired.

However, relying on amortization schedules is problematic, in part because the actual amounts the owners contribute to their funds in the future could differ (that is, worsen) from their planned amounts if economic conditions or other factors change. NRC officials said that owners are not required by regulation to report their recent actual contributions to the trust funds, and NRC does not directly monitor whether the owners' actual contributions match their planned contributions. Consequently, NRC relies on the owners' amortization schedules as reported in the biennial reports.

[18]One plant—Browns Ferry 1—has a license but is currently not operating.

Such reliance is also problematic because in developing their amortization schedules, the owners could use widely varying rates of return to project the earnings on their trust fund investments. For example, each of the three co-owners of the Duane Arnold Energy Center nuclear plant assumed a different rate, ranging from 2 to 7 percent (net of estimated cost escalation). Other factors being equal, the owners using the higher rates would need to collect fewer funds than the owner using the lower rate of return. While the return that each owner actually earns on its investments may be higher or lower than these rates, by relying on the owners' amortization schedules, NRC effectively used a different set of assumptions to evaluate the reasonableness of the trust funds accumulated by each owner. Consequently, NRC did not use a consistent "benchmark" in assessing the owners' trust funds. By contrast, we used historical trends and economic forecasts to develop assumptions about rates of earnings and other economic variables, applied the same assumptions in evaluating the adequacy of each owner's trust fund, and based expected future contributions on actual amounts contributed in recent years.

NRC's Analysis Focused on the Adequacy of Trust Funds on a Plant-by-Plant Basis

NRC's internal guidance for evaluating the biennial reports states that for plants having more than one owner, except in certain circumstances, each owner's amortization schedule should be separately assessed for its share of the plant's decommissioning costs.[19] For those plants that have co-owners, NRC used the total amount of funds accumulated for the plant as a whole in its analysis. However, as we demonstrated with our industry-wide analysis, such an assessment for determining whether owners are accumulating sufficient funds can produce misleading results because owners with more than sufficient funds can appear to balance out owners with less than sufficient funds, even though funds are generally not transferable among owners.

[19]Requirement is waived if lead owner has agreed to coordinate funding documentation and reporting for all co-owners. In such cases, the guidance does not require a separate evaluation of each co-owner's amortization schedule.

In explaining their approach, NRC officials said that the section of the guidance that calls for a separate evaluation of each owner's amortization schedule for its share of the plant is not compulsory. In addition, they said that they consider each owner's schedule to determine the total funds for the plant as a whole, but they believe that the same level of effort is not required for each individual trust fund balance unless there is a manifest reason to do so. They also stated that NRC's regulations do not prohibit each co-owner from being held responsible for decommissioning costs, even if these costs are more than the co-owner's individual ownership share. However, assessing the adequacy of decommissioning costs on a plant-wide basis is not consistent with the industry view, held by most plant owners, that each co-owner's responsibility should be limited to its pro rata share of decommissioning expenses and that NRC should not look to one owner to "bail out" another owner by imposing joint and several liability on all co-owners.[20] NRC has implicitly accepted this view and has incorporated it into policy to continue it. In a policy statement on deregulation,[21] NRC stated that it will not impose decommissioning costs on co-owners in a manner inconsistent with their agreed-upon shares,[22] except in highly unusual circumstances when required by public health and safety considerations and that it would not seek more than the pro rata shares from co-owners with *de minimis* ownership. Nevertheless, unless NRC separately evaluates each co-owner's trust fund, NRC might eventually need to look to require some owners to pay more than their share.

NRC Has Not Established Criteria for Responding to Unacceptable Levels of Financial Assurance

While the NRC has conducted two reviews of the owners' biennial reports to date, it has not established specific criteria for responding to any unacceptable levels of financial assurances that it finds in its reviews of the owners' biennial reports. As we noted in our 1999 report, without such criteria, NRC will not have a logical, coherent, and predictable plan of action if and when it encounters owners whose plants have inadequate financial assurance. NRC officials said that their oversight of the owners'

[20]Joint and several liability refers to the legal doctrine, which would allow holding all or any one of the co-owners financially responsible for the default of any co-owner.

[21]*Final Policy Statement on the Restructuring and Economic Deregulation of the Electric Utility Industry*, 62 Fed. Reg. 44071 (Aug. 19, 1997).

[22]Co-owners generally divide costs from their facilities using a contractually defined pro rata share.

decommissioning funds is an evolving process, and they are learning from their prior reviews. However, they also said that any specific changes they are considering are predecisional and final decisions have not yet been made.

The absence of any specific criteria for acting on owners' decommissioning financial reports contrasts with the agency's practices for overseeing safety activities at nuclear power plants. According to NRC, its safety assessment process allows it to integrate information relevant to licensee safety performance, make objective conclusions regarding the information, take actions based on these conclusions in a predictable manner, and effectively communicate these actions to the licensees and to the public. Its oversight approach uses criteria for identifying and responding to levels of concern for nuclear plant performance. In determining its regulatory response, NRC uses an "Action Matrix" that provides for a range of actions commensurate with the significance of inspection findings and performance indicators. If the findings indicate that a plant is operating in a way that has little or no impact on safety, then NRC implements only its baseline inspection program. However, if the findings indicate that a plant is operating in a way that implies a greater degree of safety significance, NRC performs additional inspections and initiates other actions commensurate with the significance of the safety issues. A similar approach in the area of financial assurance for decommissioning would appear to offer the same benefits of objectivity and predictability that NRC has established in its safety oversight.

Conclusions

Ensuring that nuclear power plant owners will have sufficient funds to clean up the radioactive waste hazard left behind when these plants are retired is essential for public health and safety. As our analysis identified, some owners may be at risk of not accumulating sufficient trust funds to pay for their share of decommissioning. NRC's analysis was not effective in identifying such owners because it relied too heavily on the owners' future funding plans without confirming that the plans were consistent with recent contributions. Moreover, it aggregated the owners' trust funds plant-wide instead of assessing whether each individual owner was on track to accumulate sufficient funds to pay for its share of decommissioning costs. In addition, NRC has not explained to the owners and the public what it intends to do if and when it determines an owner is not accumulating sufficient trust funds. Without a more effective method for evaluating owners' decommissioning trust funds, and without criteria for responding

to any unacceptable levels of financial assurance, NRC will not be able to effectively ensure that sufficient funds will be available when needed.

Recommendations for Executive Action

To ensure that owners are accumulating sufficient funds to decommission their nuclear power plants, we recommend that the Chairman, NRC, develop an effective method for determining whether owners are accumulating funds at sufficient rates to pay for decommissioning. For plants having more than one owner, this method should include separately evaluating whether each owner is accumulating funds at sufficient rates to pay for its share of decommissioning. We further recommend that the Chairman, NRC, establish criteria for taking action when NRC determines that an owner or co-owner is not accumulating decommissioning funds at a sufficient rate to pay for its share of the cost of decommissioning.

Agency Comments and Our Evaluation

We provided a draft of this report to NRC for its review and comment. NRC's written comments, which are reproduced in appendix III, expressed three main concerns regarding our report. First, NRC disagreed with our observation that its analyses of funding levels of the co-owners of a nuclear plant are inconsistent with its internal guidance. We revised the report to remove any inferences that NRC was not complying with its own guidance. While clarifying this point, we remained convinced that NRC needs to do more to develop an effective method for assessing the adequacy of nuclear power plant owner's trust funds for decommissioning. NRC's current practice is to combine the trust funds for all co-owners of a nuclear plant, then assess whether the combined value of the trust funds is sufficient. However, as our analysis indicates, NRC's practice of combining the trust funds of several owners for its assessment can produce misleading results because co-owners with more than sufficient funds can appear to balance out those with less than sufficient funds. As a practical matter, owners have a contractual agreement to pay their share of decommissioning costs, and owners generally cannot transfer funds from a trust fund with sufficient reserves to one without sufficient reserves. While NRC recognizes that private contractual arrangements among co-owners exist, the agency stated that it reserves the right, in highly unusual situations where adequate protection of public health and safety would be compromised if such action were not taken, to consider imposing joint and several liability on co-owners for decommissioning funding when one or more co-owners have defaulted. Nonetheless, we believe that NRC should take a proactive approach, rather than simply wait until one or more co-

owners default on their decommissioning payment expenses, to ensure that sufficient funds will be available for decommissioning and that the adequate protection of public health and safety is not compromised. Such an approach, we believe, would involve developing an effective method that, among other things, separately evaluates the adequacy of each co-owner's trust fund.

Second, NRC disagreed with our view that some owners are not on track to accumulate sufficient funds for decommissioning. NRC's position is that it has a method for assessing the reasonableness of the owners' trust funds and that our method has not been reviewed and accepted by NRC. While we recognize that NRC has neither reviewed nor accepted our method, our report identifies several limitations in NRC's method that raise doubts about whether the agency's method can effectively identify owners who might be at risk of not having sufficient funds for decommissioning. A particularly problematic aspect of this method is NRC's reliance on the owners' future funding plans to make up any shortfalls without verifying whether those plans are consistent with the owners' recent contributions. We found some owners' actual contributions in 2001 were much less than what they stated in their 2001 biennial reports to NRC that they planned to contribute. For example, one owner contributed about $1.5 million (or 39 percent) less than the amount they told NRC that they planned to contribute. In addition, based on our analysis using actual contributions the owners had recently made to their trust funds, we found that 28 owners with ownership shares in 44 different plants contributed less than the amounts we estimate they will need to make over the remaining operating life of their plants to meet their decommissioning obligations. Therefore, we continue to believe that some owners are not on track to accumulate sufficient funds to pay for decommissioning.

Finally, NRC disagreed with our view that it should establish criteria for responding to owners with unacceptable levels of financial assurance. NRC stated that its practice is to review the owners' plans on a case-by-case basis, engage in discussions with state regulators, and issue orders as necessary and appropriate. Since NRC has never identified an owner with unacceptable levels of financial assurance, it has never implemented this practice. We believe that NRC should take a more proactive approach to providing owners and the public with a more complete understanding of NRC's expectations of how it will hold owners who are not accumulating sufficient funds accountable. As stated in our draft report, this lack of criteria is in contrast to NRC's practices in overseeing safety issues at nuclear plants, where the NRC uses an "Action Matrix" that provides for a

range of actions commensurate with the significance of safety inspection findings and performance indicators. In the area of financial assurance, a similar approach could involve monitoring the trust fund deposits of those owners who NRC determines are accumulating insufficient funds to verify that the deposits are consistent with the owners' funding plans.

We conducted our review from June 2001 to September 2003 in accordance with generally accepted government auditing standards. Unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to the appropriate congressional committees; the Chairman, NRC; Director, Office of Management and Budget; and other interested parties. We will also make copies available to others upon request. In addition, this report will be available at no charge on the GAO Web site at http://www.gao.gov. If you or your staff have any questions, please call me at (202) 512-6877. Key contributors to this report are listed in appendix IV.

Sincerely yours,

Jim Wells

Jim Wells
Director, Natural Resources
and Environment

Appendix I

Scope and Methodology of Our Analysis of the Decommissioning Trust Funds

This appendix describes the scope and methodology of our review for our first objective: the extent to which nuclear power plant owners are accumulating funds at sufficient rates to pay decommissioning costs when their plants' licenses expire.

In addressing this objective, we analyzed the status of the decommissioning trust funds from two perspectives. First, we analyzed whether the industry as a whole is accumulating funds at rates that would be sufficient for decommissioning. For this analysis, we combined the trust funds of the owners of 122 nuclear plants. We then compared our results with those of our 1999 report to see whether the industry's status had changed.

Second, because owners generally cannot transfer funds from a trust fund with sufficient reserves to one without sufficient reserves, we also analyzed the status of each owner's trust fund for each plant in which the owner had an ownership share. For this analysis, we analyzed the status of 222 individual trust funds, representing 99 owners of all or parts of 122 plants.

For both the combined industry-wide trust funds and the individual owners' trust funds, we conducted two separate analyses (hereafter described in terms of our analysis of the individual owners' trust funds). This method is the same as that used in our earlier report on the adequacy of decommissioning funding.[1] First, we looked backward from a base year—2000—and assessed whether, when taking into account key economic factors such as decommissioning cost-escalation rates and after-tax rates of return on the funds (the discount rate), each owner's decommissioning fund balance for its ownership share of each of its plants was consistent with the expended portion of the licensed operating life of that plant. In other words, we assessed whether the monies the owner had contributed to its fund as of the end of 2000, together with the past earnings on these monies, equaled a benchmark or expected balance the owner should have accumulated by that time.

[1]GAO/RCED-99-75.

To determine the benchmark balance for 2000 for each plant (owner's share), we multiplied the present value of the plant's estimated future decommissioning costs (owner's share) by the fraction of the plant's operating life used up by 2000. For example, a plant that began operating in 1980 would have used up one-half of its 40-year operating life by the end of 2000. Therefore, by the end of 2000, the owner for this plant should be expected to have accumulated in its trust fund one-half of the present value (in constant 2000 dollars) of the estimated decommissioning costs. Over the life of a plant, our benchmark measure presumes that an owner would contribute an annual amount that increases (but constant in present-value terms) at the trust fund's after-tax rate of return. The sum of these annual amounts plus the income earned on the investment of the funds would equal the total estimated (present value of) the decommissioning costs when the plant's operating license expires.[2]

Although recent deregulation and restructuring of the electricity industry have led some owners to prepay decommissioning costs, many owners continue to fund the trust funds by collecting fees from electricity users. Thus, under our benchmark measure, by paying decommissioning "fees" that are deposited into the trust funds, electricity users pay for the present value of each year's accrued decommissioning costs. As a result, the benchmark embodies the principle of economic efficiency in that the price of a product (i.e., electricity) should, if possible, equal all of its costs—current and accrued. In addition, by assuming that current and future users pay the same decommissioning fees, in constant present-value terms, our benchmark ensures that decommissioning costs are accrued transparently over time.

In addition to the looking-backward analysis, we conducted a second analysis, a "looking forward" from a base year—end of 2000—and assessed

[2]We assume that decommissioning will most likely occur within 5 years of a plant being retired. For simplicity, our model therefore decommissions a plant "instantaneously" at 2.5 years after the 40-year lifespan. Thus, the present value of decommissioning costs after the first year of operation is computed by discounting the estimated future costs by 41.5 years (39+2.5). Under our benchmark, the first contribution to the fund at the end of the first year should equal 1/40th of the present value of the costs, discounted over 41.5 years. At the end of the second year of the plant's operation, the trust fund (including earnings) would equal 2/40th of the present value of the future costs, discounted back by 40.5 years. Finally, at the end of the 40th and final year of operation, the fund would contain 40/40th of the present value of the future costs, discounted back by 2.5 years. At "instantaneous" decommissioning, 2.5 years hence, the trust fund balance would equal the entire current-dollar decommissioning costs.

whether each owner's recent contributions to its decommissioning funds for respective shares of each of its nuclear power plants were at a level consistent with the remaining portions of the licensed operating lives of each plant. In other words, we assessed whether the owner recently added monies to its decommissioning trust fund for each plant at the benchmark contribution necessary to have enough funds to decommission the plant when its operating license expires. For example, an owner who is behind in terms of trust fund balance through the end of 2000 could have recently contributed to its fund at much higher rates than it had in the past to make up for its shortfall over the remaining operating life of the plant.

To determine an owner's benchmark annual contribution, for each of its plants, we computed the annual-average present value of the required future contributions that are summed over the remaining life of the plant. The total present value contribution must equal the present value of the total future decommissioning costs minus the value of the current trust fund balance. We then compared this annual amount with the average contribution to the trust fund that the owner made in 1999 and 2000 (cost adjusted to 2000). We assume that an owner will annually increase its most recent contribution (2-year average, cost adjusted to 2000) over the remaining life of its plant by the assumed after-tax rate of return on its decommissioning fund. Owners whose recent average contributions exceeded the benchmark amount would be adding funds at a rate that would be more than sufficient, while owners whose recent average contributions were below the benchmark rate would be adding funds at an insufficient rate to pay for future decommissioning costs (under our specific economic assumptions).

For our assessment of the status of the industry as a whole (and for both the looking-backward and looking-forward analyses), we developed three different scenarios: baseline (i.e., most likely), pessimistic, and optimistic. For the baseline analysis, we used our most likely economic assumptions. For the pessimistic and optimistic scenarios, we used different values for several key assumptions, as described later in this appendix.

For our assessment of the status of each individual owner's trust funds, we looked at the status of each owner's trust funds under baseline (most likely) assumptions (for both the looking-backward and looking-forward analyses). In addition, for owners who were below the benchmark on both balances and contributions under the baseline assumptions, we reviewed the 2003 and 2001 biennial reports to ascertain whether the owner has and/or had an additional method (e.g., parent company guarantee) to

support financial assurance obligations. We indicate in our detailed results when an owner reported having an additional method (see app. II, table 4). However, we did not evaluate the adequacy of these methods.

In addition, for selected owners depending upon our baseline results, we analyzed how these results might change under alternative conditions—optimistic or pessimistic assumptions. For example, for owners who were below the benchmark on both balances and contributions under the baseline (see app. II, table 5), we assessed the status of their trust funds under optimistic conditions to determine which of these owner's funds would still remain below benchmark on both our looking-backward and looking-forward measures. In addition, for owners who were from zero to 100 percent above the benchmark, under baseline assumptions for either balances or contributions, we assessed the status of their funds under pessimistic assumptions to determine whether their funds would fall below benchmarks for both balances and contributions (see app. II, table 6).[3]

Key Data Used in Analysis

To conduct our analysis we used a spreadsheet simulation model that uses a base year of 2000. In addition, for the key data in our analysis, we used the owner's 2001 biennial reports and responses from a mail survey that we administered to nuclear power plant owners.

More specifically, the key data used in the model are the following:

(1) Owner's name, percentage of each plant in which the owner has a share, year the plant was licensed to operate (or commenced operation, if earlier), and year the plant's license will expire. We obtained these data using the owners' 2001 biennial reports to Nuclear Regulatory Commission (NRC) and other NRC publications.

(2) A decommissioning cost estimate for each plant (that is, a current dollar amount for the year that the estimate was made). When available, we used a site-specific estimate of NRC-related costs (that is, radiation-related costs). If a site-specific estimate was not available, we used cost estimates derived from NRC's generic formula for these NRC-related costs. We obtained these data using the owners' 2001 biennial reports to NRC.

[3]Table 6 includes some trust funds for which we did not have contributions data but whose balance adequacy percentage for the baseline fell below zero under the pessimistic assumptions.

(3) Decommissioning fund balances as of December 31, 2000 for each owner and its plant share. When indicated, we used that portion of the fund balance that the owner designated for NRC-type costs (that is, excluding the costs relating to nonradiation or spent-fuel activities). Otherwise we used the entire fund balance. We obtained these data from the owners' responses to our survey or from their 2001 biennial reports.

(4) Decommissioning fund contributions for 1999 and 2000 for each owner and its plant share. We assumed these contributions were for NRC-related costs only. We obtained these data from the responses to our survey, and for owners who did not respond to our survey, we do not report on the adequacy of their contributions.

In some cases, the ownership shares of plants have changed hands since our survey and the 2001 biennial reports. In these cases, to make our analysis as current as possible, we assess the adequacy of the funds that were accumulated by the previous owner but report the results under the name of the new owner of the trust fund (see app. II, table 4). Nonetheless, the new owner might accumulate trust funds at a different rate than the former owner.

Key Assumptions Used in the Analysis

The analysis of the industry-wide trust funds and the individual owners' trust funds depends on the following six key assumptions. The values for these six assumptions vary based upon the scenario: baseline (most likely), pessimistic, or optimistic. For each scenario, we used the same assumption values for each owner and each plant in order to apply an "even-handed" standard.

(1) Future after-tax rate of return on decommissioning fund assets (discount rate): An after-tax rate of return was used to discount future trust fund contributions and plant decommissioning costs. In our survey, we asked owners for information on the financial assets contained in their respective decommissioning funds. We grouped these assets into five basic financial categories and calculated estimated, industry-wide, average weights for each type, these asset weights themselves reflecting the weights of the varying fund sizes. These categories, and calculated weighted-averages were: equities (e.g., common stocks), 47.1 percent; U.S. securities (e.g., federal government bonds), 26.7 percent; corporate bonds, 9.8 percent; municipal bonds, 10.4 percent; and cash and short-term instruments, 6.0 percent. Therefore, on average, these decommissioning funds contained roughly a 50-50 split between equities and bonds. We used

these results for all of the decommissioning funds, for all three scenarios, but recognize three qualifications: (1) the variation in these asset weights among individual funds for 2000 was quite large, (2) our asset composition data represent only a time "snapshot" of such allocation—for year 2000 only, and (3) these same (baseline) asset weights are also assumed for our other two scenarios, because appropriate data were lacking to do otherwise.

Using a long-term forecast from Global Insight (an economic forecasting company),[4] we developed a forecast for each asset category under a baseline, pessimistic, and optimistic forecast scenario. For the baseline scenario, we used Global Insight's trend forecast; for the pessimistic scenario, we used their pessimistic forecast (representing slower real gross domestic product (GDP) growth); and for the optimistic scenario, we used their optimistic forecast (representing faster real GDP growth).

For the baseline scenario, we calculated a forecast (current-dollar) growth rate of 6.26 percent for equities, 6.83 percent for U.S. securities, 7.83 percent for corporate bonds, 6.27 percent for municipal bonds, and 5.02 percent for cash and short-term instruments.[5] Multiplying these forecast rates with their respective asset weights in the owners' portfolios yielded a baseline "portfolio average" forecast pretax annual-average rate of return of 6.49 percent. Similarly, we calculated pretax rates of return for the pessimistic and optimistic forecasts of 7.27 percent and 6.45 percent, respectively. The rate under the pessimistic forecast is higher than the rate under the baseline or optimistic forecasts because of higher inflation in the Global Insight pessimistic forecast and because of the owners' relatively high average allocation of trust fund investments in bonds. (In Global Insight's pessimistic forecast, the nominal-rate return on bonds is greater than on equities.)

[4]Forecast as of January 30, 2003.

[5]To forecast the growth in equities, we used Global Insight's forecast for the S&P 500. We assumed that dividends would be reinvested. For example, for our baseline scenario, we combined the compound annual-average growth rate for the S&P 500 Index with its corresponding annual-average dividend yield rate to obtain a total growth rate. For U.S. securities, we used the forecast for 30-year federal government bonds. For corporate bonds and municipal bonds, we used the forecast for Aaa-rated corporate and municipal bonds, respectively. For cash, we used the forecast for 6-month U.S. Treasury Bills.

To convert the "portfolio average" forecast pretax rate of return to an after-tax rate of return, we used the pre- and post-tax rates of return data that owners provided in our survey. Based on these data we determined that the pretax rate should be reduced by 0.87 percentage points to derive a baseline after-tax rate of return of 5.62 (6.49 – 0.87) percent.[6] Similarly, we calculated an after-tax rate of return of 6.40 (7.27 – 0.87) percent for the pessimistic scenario and an after-tax rate of return of 5.58 (6.45 – 0.87) percent for the optimistic scenario.

(2) Future decommissioning cost escalation rate: For our baseline scenario, we assumed that decommissioning costs would increase annually at a nominal rate of 4.60 percent.[7] Combining the after-tax rate of return and the cost escalation rate gave us an implied real (cost-adjusted) after-tax rate of return of 1.02 (5.62 - 4.60) percent for the baseline scenario.

To calculate real after-tax rates of return for the pessimistic and optimistic scenarios, we first adjusted the nominal after-tax rates of return using Global Insight's inflation forecasts. Its annual-average inflation forecast was about 2.47 percent for trend, or baseline, 3.04 percent for pessimistic, and 2.15 percent for optimistic. Using these forecasts, the real forecast rates of return are 3.15 (5.62 - 2.47) percent for baseline, 3.36 (6.40 – 3.04) percent for pessimistic, and 3.43 (5.58 – 2.15) percent for optimistic. We then used proportionality ratios to obtain real cost adjusted after-tax rates of return of 1.09 percent for the pessimistic scenario and 1.11 percent for the optimistic scenario.[8] From these real after-tax rates of return, we

[6]Using rate of return data provided by 84 owners, we calculated a weighted-average difference between their pretax and after-tax rates of return for each fund and year over 1997-2001, weighted by the relative size of their funds. We then calculated the simple mean of the weighted average differences for each year to obtain an overall weighted average difference of about 0.87 of a percentage point.

[7]The 4.60 percent cost-escalation rate is fund-weighted average based on the owners' assumptions about future nominal-dollar cost-escalation, as reported in their 2001 biennial reports.

[8]To calculate a cost-adjusted real rate-of-return for the pessimistic and optimistic scenarios, we formed proportionality ratios. For pessimistic, 3.36% / 3.15% = x% / 1.02%; therefore, x = 1.09%. For optimistic, 3.43% / 3.15% = y% /1.02%; therefore, y = 1.11%.

computed implied cost-escalation rates of 5.31 percent and 4.47 percent for the pessimistic and optimistic scenarios, respectively.[9]

Note that the real (cost-adjusted) after-tax rates of return are quite similar in value among our scenarios; therefore, any differing effect on model results caused by the combination of the fund rate of return and decommissioning cost-escalation assumptions will be fairly minimal. Nonetheless, all other things being equal, for these two assumptions only, the balance and contribution adequacy results for the pessimistic scenario will be slightly above those of the baseline scenario, and only slightly below those of the optimistic scenario.

(3) Alternative initial decommissioning cost estimates: In our baseline scenario, for the "initial" decommissioning (NRC-related) costs, we used the site-specific estimates when available. Otherwise, we used the cost estimates derived from NRC's generic formula. For the pessimistic and optimistic scenarios, we used professional judgment to adjust the estimate used in the baseline. For example, to reflect a general concern among industry observers that future decommissioning costs could be much higher than expected, we increased the initial cost estimate by 40 percent for the pessimistic scenario, and reduced the initial decommissioning cost estimate by only 5 percent for the optimistic scenario.

(4) Alternative start of decommissioning–years after shutdown: For the baseline scenario, we assumed that decommissioning would occur within the immediate 5 years after license termination; for simplification, we assumed "instantaneous" decommissioning at 2.5 years after shutdown.[10] For the pessimistic assumption, decommissioning is assumed to occur within the first 4 years—at 2 years after shutdown. For the optimistic assumption, we assumed a 5-year delayed start of decommissioning—within 5-10 years after license termination—at 7.5 years after shutdown. Under certain circumstances (e.g., co-located plants), NRC may permit a decommissioning delay. As long as the assumed after-tax rate of return exceeds the assumed cost-escalation rate (i.e., a positive, real, cost-

[9]For pessimistic, 6.40% - x% = 1.09%; therefore, x = 5.31%. For optimistic, 5.58% - y% = 1.11%; therefore, y = 4.47%.

[10]To test this simplifying assumption in the looking-backward analysis, we assessed the impact of assuming that one-fifth of decommissioning occurred over each of the 5 years. The result was virtually identical to that obtained when we assumed that all decommissioning occurred at 2.5 years after shutdown.

adjusted rate of return), a delay in decommissioning will improve the outlook for an owner's trust fund in both the looking-backward (trust fund balance) and looking-forward (trust fund contributions) analysis, all else the same.

(5) Alternative operating license expiration year: The year of plant operating-license expiration is assumed to vary among our three scenarios to reflect that NRC has approved license renewals for some plants, and it may approve 20-year license renewals for other plants in the future. For the baseline and pessimistic scenarios, we include the renewals that have been approved for 16 plants, as of August 20, 2003.[11] In addition, because NRC has received renewal applications from owners of 14 plants, and it anticipates applications from owners of another 8 plants by the end of 2003 (as of August 20, 2003), we assume in the optimistic scenario that license renewals will be approved for an additional 22 plants.[12] In general, these plant license renewals suggest that the electricity market today is robust and owners expect higher electricity prices in the future.[13]

(6) Alternative market values for decommissioning funds: For the baseline and optimistic scenarios, we use the actual market value of the trust fund balances as of the end of 2000. In contrast, for the pessimistic scenario, we reduced the actual market value of the funds by 5 percent for 2000 to simulate the effect of a slowing economy on investment returns from 2000 through 2002. The simulated decline is modest, and over the period, the overall increase in bond prices would have offset to some degree the overall decline in the value of common stocks.

[11]The 16 plants are: Arkansas Nuclear Unit 1; Calvert Cliffs Units 1 and 2; Hatch Units 1 and 2; North Anna Units 1 and 2; Oconee Units 1, 2, and 3; Peach Bottom Units 2 and 3; Surry Units 1 and 2; and Turkey Point Units 3 and 4.

[12]The 14 plants are: Catawba Units 1 and 2; Dresden Units 2 and 3; Fort Calhoun; Ginna; McGuire Units 1 and 2; Quad Cities Units 1 and 2; Robinson 2; St. Lucie Units 1 and 2; and Summer. The other 8 plants are: Arkansas Nuclear Unit 2; Browns Ferry Units 1, 2, and 3; Cook, D.C. Units 1 and 2; and Farley Units 1 and 2.

[13]This expectation is in contrast to conditions reported in our 1999 report, when the market for electricity appeared much weaker. In that report, we assumed in the baseline scenario that 6 plants would be prematurely retired during 1998 to 2002.

Detailed Results of Our Analysis of the Decommissioning Trust Funds

This appendix presents the detailed results of our analysis of the decommissioning trust funds. Specifically, table 3 shows industry-wide, weighted-average results under three scenarios—baseline (most likely) assumptions, pessimistic assumptions, and optimistic assumptions. Table 4 presents the results for individual owners under baseline, or most likely assumptions. Table 5 shows the results of our analysis under optimistic assumptions for individual owners whose trust funds were below the benchmarks for both balances and recent contributions under the baseline scenario. Table 6 presents the results under pessimistic assumptions for individual owners whose trust funds were zero to 100 percent above the benchmark balances and/or contributions under the baseline scenario. See appendix I for a description of our methodology.

Table 3: Status of Combined Trust Funds Compared with Benchmarks for Balances and Contributions (by Percentage above or below Benchmarks)

			Scenario		
Analysis category	Number of owners	Number of plants	Baseline[a] (percent)	Pessimistic[a] (percent)	Optimistic[b] (percent)
Balances through 2000	99	122	46.9	0.2	82.5
Recent Contributions[c]	75	109	106.5	-18.0	224.4

Source: GAO analysis.

Note: Percentages are weighted averages, measured relative to the benchmark balances or benchmark contributions.

[a]The baseline and pessimistic scenarios include the 20-year license renewals already granted for 16 plants, as of August 20, 2003.

[b]The optimistic scenario includes 20-year license renewals for 38 plants, including renewals: (1) already granted for 16 plants, (2) for another 14 plants whose owners have applied for but not yet received renewals, and (3) for another 8 plants whose owners are expected to apply by December 2003 (all as of August 20, 2003).

[c]Adequacy of recent contributions is based on responses to our survey. The percentages are more, or less, than the benchmark contribution, meaning the owner has contributed more, or less, on average for 1999 and 2000 (cost adjusted to 2000) than the annual average of the present value of the amounts required in each subsequent year until the plant's license expires.

Table 4: Owners with More, or Less, Than Benchmark Trust Fund Balances and Contributions, under Most Likely Assumptions (by Percentage above or below Benchmarks)

			Baseline (most likely) scenario	
Plant name	Owner	Ownership share of plant (percent)	Adequacy of trust fund balances as of end of 2000	Adequacy of recent trust fund contributions[a]
Arkansas Nuclear 1[b]	Entergy Arkansas, Inc.	100	+ + + +	+ + + +
Arkansas Nuclear 2[c]	Entergy Arkansas, Inc.	100	+	–
Beaver Valley 1	Ohio Edison Co.	35	+	+
Beaver Valley 1	Pennsylvania Power Co.	65	–	– – –
Beaver Valley 2	Cleveland Electric Illuminating Co.	24.47	+ +	+
Beaver Valley 2	Ohio Edison Co.	41.88	+ +	–
Beaver Valley 2	Pennsylvania Power Co.	13.74	+ + + +	– – –
Beaver Valley 2	Toledo Edison Co.	19.91	+ +	+ +
Big Rock Point[d]	Consumers Energy Co.	100	+	+ + + +[e]
Braidwood 1	Exelon Generation Co., LLC	100	+ + +	– – –
Braidwood 2	Exelon Generation Co., LLC	100	+ + + +	+ + + +
Browns Ferry 1[c]	Tennessee Valley Authority	100	– –	– – –
Browns Ferry 2[c]	Tennessee Valley Authority	100	– –	– – –
Browns Ferry 3[c]	Tennessee Valley Authority	100	– –	– – –
Brunswick 1	North Carolina Eastern Municipal	18.33	–	+
Brunswick 1[f]	Progress Energy Carolinas, Inc.	81.67	– –	–
Brunswick 2	North Carolina Eastern Municipal	18.33	–	+
Brunswick 2[f]	Progress Energy Carolinas, Inc.	81.67	– –	+
Byron 1	Exelon Generation Co., LLC	100	+ + +	– – –
Byron 2	Exelon Generation Co., LLC	100	+ + +	+ + +
Callaway	AmerenUE	100	+	– –
Calvert Cliffs 1[b]	Constellation Energy Group	100	+	[g]
Calvert Cliffs 2[b]	Constellation Energy Group	100	+	[g]
Catawba 1[h]	Duke Power Co.	12.50	+	+ + +
Catawba 1[h]	North Carolina Electric Membership	28.1	+	– – –
Catawba 1[h]	North Carolina Municipal Power	37.50	+ +	+
Catawba 1[h]	Piedmont Municipal Power Agency	12.50	+	+ +
Catawba 1[h]	Saluda River Electric Cooperative	9.38	+ + + +	– – –
Catawba 2[h]	Duke Power Co.	12.5	+ +	+ + + +

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			Baseline (most likely) scenario	
Plant name	Owner	Ownership share of plant (percent)	Adequacy of trust fund balances as of end of 2000	Adequacy of recent trust fund contributions[a]
Catawba 2[h]	North Carolina Electric Membership	28.1	+	– – –
Catawba 2[h]	North Carolina Municipal Power	37.5	+ + +	+
Catawba 2[h]	Piedmont Municipal Power Agency	12.5	+ +	+ + +
Catawba 2[h]	Saluda River Electric Cooperative	9.38	+ + + +	– – –
Clinton	AmerGen Energy Co., Inc.	100	+ + + +	+ + +
Columbia Generating Station	Energy Northwest	100	–	– –
Comanche Peak 1	Texas Utility Electric Co.	100	+ + + +	+ + + +
Comanche Peak 2	Texas Utility Electric Co.	100	+ + + +	+ + + +
Cook, D.C. 1[c]	Indiana Michigan Power Co.	100	+ + +	+ + + +[e]
Cook, D.C. 2[c]	Indiana Michigan Power Co.	100	+ + +	+ + + +
Cooper	Nebraska Public Power District	100	+	+ + + +
Crystal River 3	City of Alachua Electric Dept.	0.08	+	[g]
Crystal River 3	City of Bushnell Utility Dept.	0.04	+ +	[g]
Crystal River 3	City of Gainesville Regional Utilities	1.41	+	+ + + +
Crystal River 3	City of Kissimmee Utilities	0.68	+	[g]
Crystal River 3	City of Leesburg Municipal Electric	0.82	+	[g]
Crystal River 3	City of Ocala Utilities Division	1.33	+	[g]
Crystal River 3	New Smyrna Beach Utilities Comm.	0.56	+ + +	+ + + +[e]
Crystal River 3	Orlando Utilities Comm.	1.60	+ + +	[g]
Crystal River 3	Progress Energy Florida	91.8	+ + +	+ + + +[e]
Crystal River 3	Seminole Electric Cooperative, Inc.	1.7	+ +	+ + +
Davis-Besse	Cleveland Electric Illuminating Co.	51.38	+	+ + + +
Davis-Besse	Toledo Edison Co.	48.62	+	+ + + +
Diablo Canyon 1	Pacific Gas & Electric Co.	100	+ + + +	+ + + +[e]
Diablo Canyon 2	Pacific Gas & Electric Co.	100	+ + + +	+ + + +[e]
Dresden 1[d]	Exelon Generation Co., LLC	100	– – –	– – –
Dresden 2[h]	Exelon Generation Co., LLC	100	+	+ + + +
Dresden 3[h]	Exelon Generation Co., LLC	100	+	+ + + +
Duane Arnold	Central Iowa Power Cooperative	20	– – –	– – –
Duane Arnold	Corn Belt Power Cooperative	10	– –	– –
Duane Arnold	IPL	70	– –	– –
Farley 1[c]	Alabama Power Co.	100	+	+ + + +

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			Baseline (most likely) scenario	
Plant name	Owner	Ownership share of plant (percent)	Adequacy of trust fund balances as of end of 2000	Adequacy of recent trust fund contributions[a]
Farley 2[c]	Alabama Power Co.	100	+ +	+ + + +
Fermi 1[d]	Detroit Edison Co.	100	–	– – –
Fermi 2	Detroit Edison Co.	100	+ + +	+ + + +
FitzPatrick	Entergy Nuclear Operations, Inc.	100	+ + +	+ + + +[e]
Fort Calhoun[h]	Omaha Public Power District	100	+	+ + + +
Ginna[h]	Rochester Gas & Electric Corp.	100	–	[g]
Grand Gulf 1	South Mississippi Electric Power	10	– –	– – –
Grand Gulf 1	System Energy Resources, Inc.	90	+	+ + + +
Haddam Neck[d]	Connecticut Yankee Atomic Power Co.	100	+	+ + + +[e]
Harris 1	North Carolina Eastern Municipal	16.17	+	–
Harris 1	Progress Energy Carolinas, Inc.	83.83	+	+
Hatch 1[b]	City of Dalton (Georgia)	2.2	+ + + +	[e, g]
Hatch 1[b]	Georgia Power Co.	50.1	+ + +	+ + + +
Hatch 1[b]	Municipal Electric Authority of Georgia	17.7	+ + +	+ + + +
Hatch 1[b]	Oglethorpe Power Co.	30	+ + +	+ + + +
Hatch 2[b]	City of Dalton (Georgia)	2.2	+ + + +	[e, g]
Hatch 2[b]	Georgia Power Co.	50.1	+ + + +	+ + + +
Hatch 2[b]	Municipal Electric Authority of Georgia	17.7	+ + + +	+ + + +
Hatch 2[b]	Oglethorpe Power Co.	30	+ + +	+ +
Hope Creek 1	PSEG Nuclear, LLC	100	+ + + +[i]	[g]
Humboldt Bay 3[d]	Pacific Gas & Electric Co.	100	+	+ + + +[e]
Indian Point 1[d, i]	Entergy Nuclear Operations, Inc.	100	– – –[i]	– – –[i]
Indian Point 2	Entergy Nuclear Operations, Inc.	100	+	+ + + +
Indian Point 3	Entergy Nuclear Operations, Inc.	100	+ + +	+ + + +[e]
Kewaunee	Wisconsin Power & Light	41	+ + + +	+ + + +[e]
Kewaunee	Wisconsin Public Service Corporation	59	+ + + +[i]	+ + + +[e, i]
LaCrosse[d, f]	Dairyland Power Cooperative	100	–	– – –
LaSalle County 1	Exelon Generation Co., LLC	100	+ + +	–
LaSalle County 2	Exelon Generation Co., LLC	100	+ + +	+ + +
Limerick 1[j]	Exelon Generation Co., LLC	100	–	– – –
Limerick 2[j]	Exelon Generation Co., LLC	100	–	–
Maine Yankee[d]	Maine Yankee Atomic Power Co.	100	– –	– –

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			Baseline (most likely) scenario	
Plant name	Owner	Ownership share of plant (percent)	Adequacy of trust fund balances as of end of 2000	Adequacy of recent trust fund contributions[a]
McGuire 1[h]	Duke Power Co.	100	+	+ + +
McGuire 2[h]	Duke Power Co.	100	+	+ + + +
Millstone 1[d, f, j]	Dominion Nuclear Connecticut	100	–	[g]
Millstone 2	Dominion Nuclear Connecticut	100	+ +	[g]
Millstone 3	Central Vermont Public Service Corp.	1.73	+ + + +	[g]
Millstone 3	Dominion Nuclear Connecticut	93.47	+ + + +	[e, g]
Millstone 3	Massachusetts Municipal Wholesale Electric Co.	4.80	+ + + +	[g]
Monticello	Xcel Energy	100	–	+ +
Nine Mile Point 1[f]	Constellation Energy Group	100	–[j]	[g]
Nine Mile Point 2	Constellation Energy Group	82	+ + +[j]	[g]
Nine Mile Point 2	Long Island Power Authority	18	+ + +	+ + + +
North Anna 1[b, k]	Old Dominion Cooperative	10.4	+ + + +	[e, g]
North Anna 1[b, k]	Virginia Electric & Power Co.	89.6	+ + + +	+ + + +
North Anna 2[b, k]	Old Dominion Cooperative	10.4	+ + + +	[e, g]
North Anna 2[b, k]	Virginia Electric & Power Co.	89.6	+ + + +	+ + + +
Oconee 1[b]	Duke Power Co.	100	+ +	+ + + +
Oconee 2[b]	Duke Power Co.	100	+ +	+ + + +
Oconee 3[b]	Duke Power Co.	100	+ + +	+ + + +
Oyster Creek	AmerGen Energy Co., Inc.	100	+ + +	+ + + +[e]
Palisades	Consumers Energy Co.	100	+ + + +	+ + + +[e]
Palo Verde 1	Arizona Public Service Co.	29.1	+ + +	+ + + +
Palo Verde 1	El Paso Electric Co.	15.8	–	+
Palo Verde 1	Los Angeles Dept. of Water & Power	5.7	+ + + +	+ + + +[e]
Palo Verde 1	Public Service Company of New Mexico	10.2	+ +	+ + + +
Palo Verde 1	Salt River Project Agricultural Improvement & Power District	17.49	+ + +	[g]
Palo Verde 1	Southern California Edison Co.	15.8	+ + + +	[e, g]
Palo Verde 1	Southern California Public Power	5.91	+ + + +	+ + + +[e]
Palo Verde 2	Arizona Public Service Co.	29.1	+ + +	+ + + +
Palo Verde 2	El Paso Electric Co.	15.8	–	–

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			Baseline (most likely) scenario	
Plant name	Owner	Ownership share of plant (percent)	Adequacy of trust fund balances as of end of 2000	Adequacy of recent trust fund contributions[a]
Palo Verde 2	Los Angeles Dept. of Water & Power	5.70	+ + + +	+ + + +[e]
Palo Verde 2	Public Service Company of New Mexico	10.2	+ +	+ + +
Palo Verde 2	Salt River Project Agricultural Improvement & Power District	17.49	+ + +	[g]
Palo Verde 2	Southern California Edison Co.	15.8	+ + + +	[e, g]
Palo Verde 2	Southern California Public Power	5.91	+ + + +	+ + + +[e]
Palo Verde 3	Arizona Public Service Co.	29.1	+ + +	+ + +
Palo Verde 3	El Paso Electric Co.	15.80	–	+
Palo Verde 3	Los Angeles Dept. of Water & Power	5.7	+ + + +	+ + + +[e]
Palo Verde 3	Public Service Company of New Mexico	10.2	+ +	– – –
Palo Verde 3	Salt River Project Agricultural Improvement & Power District	17.49	+ + +	[g]
Palo Verde 3	Southern California Edison Co.	15.8	+ + + +	[e, g]
Palo Verde 3	Southern California Public Power	5.91	+ + + +	+ + + +[e]
Peach Bottom 1[d, j]	Exelon Generation Co., LLC	100	– – –	– – –
Peach Bottom 2[b, j]	Exelon Generation Co., LLC	50	+ +[i]	+ + +
Peach Bottom 2[b]	PSEG Nuclear, LLC	50	+ + +[i]	[g]
Peach Bottom 3[b, j]	Exelon Generation Co., LLC	50	+ + +[i]	+ + + +
Peach Bottom 3[b]	PSEG Nuclear, LLC	50	+ + + +[i]	[g]
Perry 1	Cleveland Electric Illuminating Co.	44.85	+ + +	+ + + +
Perry 1	Ohio Edison Co.	30	+ +	+ + +
Perry 1	Pennsylvania Power Co.	5.24	+	+ + +
Perry 1	Toledo Edison Co.	19.91	+ +	+ + + +
Pilgrim 1	Entergy Nuclear Operations, Inc.	100	+ +	– – –
Point Beach 1	Wisconsin Electric Power Co.	100	+ + +	+ + + +[e]
Point Beach 2	Wisconsin Electric Power Co.	100	+ + +	+ + + +[e]
Prairie Island 1	Xcel Energy	100	+	+ + + +
Prairie Island 2	Xcel Energy	100	+	+ + + +
Quad Cities 1[h]	Exelon Generation Co., LLC	75	+	+ +
Quad Cities 1[h]	MidAmerican Energy Holdings Co.	25	+ +	+ + + +
Quad Cities 2[h]	Exelon Generation Co., LLC	75	+	+ + + +
Quad Cities 2[h]	MidAmerican Energy Holdings Co.	25	–	+

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			Baseline (most likely) scenario	
Plant name	Owner	Ownership share of plant (percent)	Adequacy of trust fund balances as of end of 2000	Adequacy of recent trust fund contributions[a]
Rancho Seco[d]	Sacramento Municipal Utility District	100	– –	– – –
River Bend 1	Entergy Gulf States, Inc.	100	+ + + +	+ + + +
Robinson 2[f, h]	Progress Energy Carolinas, Inc.	100	– –	– –
Salem 1	Exelon Generation Co., LLC	42.59	–	– –
Salem 1	PSEG Nuclear, LLC	57.41	+ + +[i]	[e, g]
Salem 2	Exelon Generation Co., LLC	42.59	–	–
Salem 2	PSEG Nuclear, LLC	57.41	+ + +[i]	[g]
San Onofre 1[d]	San Diego Gas & Electric Co.	20	+ + + +	[e, g]
San Onofre 1[d]	Southern California Edison Co.	80	+ + +	[e, g]
San Onofre 2	Anaheim Public Utilities Dept.	3.16	+ + + +	[e, g]
San Onofre 2	Riverside Utilities Dept.	1.79	+ + + +	[e, g]
San Onofre 2	San Diego Gas & Electric Co.	20	+ + + +	[e, g]
San Onofre 2	Southern California Edison Co.	75.05	+ + + +	[e, g]
San Onofre 3	Anaheim Public Utilities Dept.	3.16	+ + + +	[e, g]
San Onofre 3	Riverside Utilities Dept.	1.79	+ + + +	[e, g]
San Onofre 3	San Diego Gas & Electric Co.	20	+ + + +	[e, g]
San Onofre 3	Southern California Edison Co.	75.05	+ + + +	[e, g]
Saxton[d]	GPU Nuclear	100	+ + + +	[e, g]
Seabrook 1	FPL Energy	88.2	+ + +[i]	+ + + +[i]
Seabrook 1	Hudson Light & Power Dept.	0.08	+ +	+ + + +
Seabrook 1	Massachusetts Municipal Wholesale Electric Co.	11.6	+ +	+ + +
Seabrook 1	Taunton Municipal Lighting Plant	0.1	+ +	+ + + +
Sequoyah 1	Tennessee Valley Authority	100	–	– – –
Sequoyah 2	Tennessee Valley Authority	100	–	– – –
South Texas Project 1	AEP (Texas Central Co.)	25.20	+ + + +[i]	+ + + +[i]
South Texas Project 1	City of Austin—Austin Energy	16	+ + + +	+ + + +
South Texas Project 1	City Public Service Board of San Antonio	28	+ + +	+ + + +
South Texas Project 1	Texas Genco	30.80	+ + + +[i]	+ + + +[i]
South Texas Project 2	AEP (Texas Central Co.)	25.20	+ + + +[i]	+ + + +[i]
South Texas Project 2	City of Austin—Austin Energy	16	+ + + +	+ + + +
South Texas Project 2	City Public Service Board of San Antonio	28	+ + + +	+ + + +

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Plant name	Owner	Ownership share of plant (percent)	Baseline (most likely) scenario: Adequacy of trust fund balances as of end of 2000	Baseline (most likely) scenario: Adequacy of recent trust fund contributions[a]
South Texas Project 2	Texas Genco	30.80	+ + + +[i]	+ + + +[e, i]
St Lucie 1[h]	Florida Power & Light Co.	100	+ + + +	+ + + +[e]
St Lucie 2[h]	Florida Municipal Power Agency	8.7	+ + +	[g]
St Lucie 2[h]	Florida Power & Light Co.	85.2	+ + + +	+ + + +[e]
St Lucie 2[h]	Orlando Utilities Comm.	6.05	+ + + +	[e, g]
Summer[h]	South Carolina Electric & Gas Co.	66.67	− −	− − −
Summer[h]	South Carolina Public Service Authority	33.33	+	+ + + +
Surry 1[b]	Virginia Electric & Power Co.	100	+ + +	+ + + +
Surry 2[b]	Virginia Electric & Power Co.	100	+ + +	+ + + +
Susquehanna 1	Allegheny Electric Cooperative	10	− −	−
Susquehanna 1	PPL Susquehanna, LLC	90	+	+
Susquehanna 2	Allegheny Electric Cooperative	10	− −	−
Susquehanna 2	PPL Susquehanna, LLC	90	+	+ + + +
Three Mile Island 1	AmerGen Energy Co., Inc.	100	+ + +	+ + + +[e]
Three Mile Island 2[d]	Jersey Central Power & Light	25	−[i]	[g]
Three Mile Island 2[d]	Metropolitan Edison Co.	50	−[i]	[g]
Three Mile Island 2[d]	Pennsylvania Electric Co.	25	−[i]	[g]
Trojan[d, f, j]	Eugene Water & Electric Board	30	− − −	[g]
Trojan[d, f, j]	Pacific Power & Light Co.	2.50	−	+ + + +
Trojan[d, f, j]	Portland General Electric Co.	67.50	− − −	− − −
Turkey Point 3[b]	Florida Power & Light Co.	100	+ + + +	+ + + +[e]
Turkey Point 4[b]	Florida Power & Light Co.	100	+ + + +	+ + + +[e]
Vermont Yankee	Entergy Nuclear Operations, Inc.	100	+[i]	+ + +[i]
Vogtle 1	City of Dalton (Georgia)	1.60	+ + + +	[e, g]
Vogtle 1	Georgia Power Co.	45.70	+ + + +	+ + + +
Vogtle 1	Municipal Electric Authority of Georgia	22.70	+ + + +	+ + + +
Vogtle 1	Oglethorpe Power Co.	30	+	− − −
Vogtle 2	City of Dalton (Georgia)	1.60	+ + + +	[e, g]
Vogtle 2	Georgia Power Co.	45.70	+ + + +	+ + + +
Vogtle 2	Municipal Electric Authority of Georgia	22.70	+ + + +	+ + + +

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Plant name	Owner	Ownership share of plant (percent)	Baseline (most likely) scenario: Adequacy of trust fund balances as of end of 2000	Baseline (most likely) scenario: Adequacy of recent trust fund contributions[a]
Vogtle 2	Oglethorpe Power Co.	30	_	_ _ _
Waterford 3	Entergy Louisiana, Inc.	100	_	+
Watts Bar 1	Tennessee Valley Authority	100	+ + + +	_ _ _
Wolf Creek 1	Kansas City Power & Light Co.	47	+	_
Wolf Creek 1	Kansas Electric Power Cooperative	6	_ _	_ _ _
Wolf Creek 1	Kansas Gas & Electric Co.	47	+	+
Yankee Rowe[d]	Yankee Atomic Electric Co.	100	_	+ + + +
Zion 1[d]	Exelon Generation Co., LLC	100	_ _	_ _ _
Zion 2[d]	Exelon Generation Co., LLC	100	_ _ _	_ _ _

Legend

+ means that fund balance/recent contributions were 0 to 25 percent more than benchmark.

++ means that fund balance/recent contributions were 26 to 50 percent more than benchmark.

+++ means that fund balance/recent contributions were 51 to 100 percent more than benchmark.

++++ means that fund balance/recent contributions were 101 percent or more than benchmark.

_ means that fund balance/recent contributions were 0.1 to 25 percent less than benchmark.

_ _ means that fund balance/recent contributions were 26 to 50 percent less than benchmark.

_ _ _ means that fund balance/recent contributions were 51 to 100 percent less than benchmark.

Source: GAO analysis.

[a]Adequacy of recent contributions is based on responses to our survey. The percentages are more, or less, than the benchmark, meaning the owner has contributed more, or less, on average for 1999 and 2000 (cost adjusted to 2000) than the annual average of the present value amounts required in each subsequent year until its plant is retired.

[b]Plant's operating license extended for 20 years.

[c]Plants whose owners are expected to apply for 20-year license renewals by December 2003.

[d]Plant has permanently shut down.

[e]Trust fund balance exceeds present value of estimated decommissioning costs.

[f]Owner has, as of March 31, 2003, an additional method to support financial assurance obligations (e.g., parent company guarantee, statement of intent).

[g]Contributions data are not available.

[h]Plants whose owners have applied for 20-year license renewals, as of August 20, 2003.

[i]Includes balances and/or contributions from a previous owner's biennial report and/or responses to our survey.

[j]Owner had, as of March 31, 2001, an additional method to support financial assurance obligations (e.g., parent company guarantee, statement of intent).

[k]Liability is for decommissioning share and not ownership share.

Table 5: Selected Owners with More, or Less, Than Benchmark Trust Fund Balances and Contributions, under Optimistic Assumptions (by Percentage above or below Benchmarks)

			Optimistic scenario[b]	
Plant name	**Owner[a]**	**Ownership share of plant (percent)**	**Adequacy of trust fund balances as of end of 2000**	**Adequacy of recent trust fund contributions[c]**
Beaver Valley 1	Pennsylvania Power Co.	65	+	– – –
Browns Ferry 1[d]	Tennessee Valley Authority	100	+ +	– – –
Browns Ferry 2[d]	Tennessee Valley Authority	100	+ +	– – –
Browns Ferry 3[d]	Tennessee Valley Authority	100	+ +	– – –
Brunswick 1	Progress Energy Carolinas, Inc.	81.67	–	+
Columbia Generating Station	Energy Northwest	100	–	– –
Dresden 1[e]	Exelon Generation Co., LLC	100	– – –	– – –[g]
Duane Arnold	Central Iowa Power Cooperative	20	– – –	– – –
Duane Arnold	Corn Belt Power Cooperative	10	– –	– –
Duane Arnold	IPL	70	–	–
Fermi 1[e]	Detroit Edison Co.	100	+	+ + + +[f]
Grand Gulf 1	South Mississippi Electric Power	10	–	– – –
Indian Point 1[e]	Entergy Nuclear Operations, Inc.	100	– – –[g]	– – –[g]
LaCrosse[e]	Dairyland Power Cooperative	100	+	+ + + +[f]
Limerick 1	Exelon Generation Co., LLC	100	–	– –
Limerick 2	Exelon Generation Co., LLC	100	–	+
Maine Yankee[e]	Maine Yankee Atomic Power Co.	100	–	–
Palo Verde 2	El Paso Electric Co.	15.80	+	+
Peach Bottom 1[e]	Exelon Generation Co., LLC	100	– – –	– – –
Rancho Seco[e]	Sacramento Municipal Utility District	100	– –	– – –
Robinson 2[d]	Progress Energy Carolinas, Inc.	100	+	+ + + +
Salem 1	Exelon Generation Co., LLC	42.59	–	–
Salem 2	Exelon Generation Co., LLC	42.59	+	+
Sequoyah 1	Tennessee Valley Authority	100	–	– – –
Sequoyah 2	Tennessee Valley Authority	100	+	– – –
Summer[d]	South Carolina Electric & Gas Co.	66.67	+ +	+ +

(Continued From Previous Page)

			Optimistic scenario[b]	
Plant name	Owner[a]	Ownership share of plant (percent)	Adequacy of trust fund balances as of end of 2000	Adequacy of recent trust fund contributions[c]
Susquehanna 1	Allegheny Electric Cooperative	10	_ _	+
Susquehanna 2	Allegheny Electric Cooperative	10	_ _	+
Trojan[e]	Portland General Electric Co.	67.50	_ _	_ _
Vogtle 2	Oglethorpe Power Co.	30	+	_ _ _
Wolf Creek 1	Kansas Electric Power Cooperative	6	_ _	_ _
Zion 1[e]	Exelon Generation Co., LLC	100	_ _	_ _ _
Zion 2[e]	Exelon Generation Co., LLC	100	_ _	_ _ _

Legend

+ means that fund balance/recent contributions were 0 to 25 percent more than benchmark.

++ means that fund balance/recent contributions were 26 to 50 percent more than benchmark.

+++ means that fund balance/recent contributions were 51 to 100 percent more than benchmark.

++++ means that fund balance/recent contributions were 101 percent or more than benchmark.

_ means that fund balance/recent contributions were 0.1 to 25 percent less than benchmark.

_ _ means that fund balance/recent contributions were 26 to 50 percent less than benchmark.

_ _ _ means that fund balance/recent contributions were 51 to 100 percent less than benchmark.

Source: GAO analysis.

[a]Owners' funds were selected to be screened under optimistic assumptions based on our baseline results; namely, that the status of their trust funds was below baseline benchmarks on both balances and contributions.

[b]See appendix I for description of optimistic assumptions.

[c]Adequacy of recent contributions is based on responses to our survey. The percentages are more, or less, than the benchmark, meaning the owner has contributed more, or less, on average for 1999 and 2000 (cost adjusted to 2000) than the annual average of the present value amounts required in each subsequent year until its plant is retired.

[d]Plant whose owners have applied for 20-year license renewals or are expected to apply by December 2003, as of August 20, 2003.

[e]Plant has permanently shut down.

[f]Trust fund balance exceeds present value of estimated decommissioning cost.

[g]Includes balances and/or contributions from a previous owner's biennial report and/or responses to our survey.

Table 6: Selected Owners with More, or Less, Than Benchmark Trust Fund Balances and Contributions, under Pessimistic Assumptions (by Percentage above or below Benchmarks)

			Pessimistic assumptions scenario[b]	
Plant name	Owner[a]	Ownership share of plant (percent)	Adequacy of trust fund balances as of end of 2000	Adequacy of recent trust fund contributions[c]
Arkansas Nuclear 2[d]	Entergy Arkansas, Inc.	100	–	– – –
Beaver Valley 1	Ohio Edison Co.	35	– –	– – –
Beaver Valley 2	Cleveland Electric Illuminating Co.	24.47	–	– –
Beaver Valley 2	Ohio Edison Co.	41.88	–	– –
Beaver Valley 2	Toledo Edison Co.	19.91	–	–
Big Rock Point[e]	Consumers Energy Co.	100	– –	– – –
Brunswick 1	North Carolina Eastern Municipal	18.33	– –	– –
Brunswick 2	North Carolina Eastern Municipal	18.33	– –	– –
Brunswick 2	Progress Energy Carolinas, Inc.	81.67	– –	– –
Callaway	AmerenUE	100	– –	– – –
Calvert Cliffs 1[f]	Constellation Energy Group	100	–	[g]
Calvert Cliffs 2[f]	Constellation Energy Group	100	–	[g]
Catawba 1[d]	Duke Power Co.	12.50	–	–
Catawba 1[d]	North Carolina Electric Membership	28.1	– –	– – –
Catawba 1[d]	Piedmont Municipal Power Agency	12.5	–	–
Catawba 2[d]	North Carolina Electric Membership	28.1	–	– – –
Crystal River 3	City of Alachua Electric Dept.	0.08	–	[g]
Crystal River 3	City of Bushnell Utility Dept.	0.04	–	[g]
Crystal River 3	City of Kissimmee Utilities	0.68	– –	[g]
Crystal River 3	City of Leesburg Municipal Electric	0.82	– –	[g]
Crystal River 3	City of Ocala Utilities Division	1.33	– –	[g]
Crystal River 3	Seminole Electric Cooperative, Inc.	1.70	–	– –
Dresden 2[d]	Exelon Generation Co., LLC	100	–	–
Dresden 3[d]	Exelon Generation Co., LLC	100	–	–
Farley 1[d]	Alabama Power Co.	100	–	–

(Continued From Previous Page)

			Pessimistic assumptions scenario[b]	
Plant name	Owner[a]	Ownership share of plant (percent)	Adequacy of trust fund balances as of end of 2000	Adequacy of recent trust fund contributions[c]
Haddam Neck[e]	Connecticut Yankee Atomic Power Co.	100	_	_ _ _
Harris 1	North Carolina Eastern Municipal	16.17	_	_ _
Harris 1	Progress Energy Carolinas, Inc.	83.83	_	_ _
Humboldt Bay 3[e]	Pacific Gas & Electric Co.	100	_ _	_ _ _
Indian Point 2	Entergy Nuclear Operations, Inc.	100	_	_
Millstone 2	Dominion Nuclear Connecticut	100	_	[g]
Monticello	Xcel Energy	100	_ _	_ _
Palo Verde 1	El Paso Electric Co.	15.8	_ _	_ _
Palo Verde 3	El Paso Electric Co.	15.8	_ _	_ _
Palo Verde 3	Public Service Co. of New Mexico	10.20	_	_ _ _
Peach Bottom 2[f]	Exelon Generation Co., LLC	50	_[h]	_
Pilgrim 1	Entergy Nuclear Operations, Inc.	100	_	_ _ _
Prairie Island 1	Xcel Energy	100	_	_
Quad Cities 1[d]	Exelon Generation Co., LLC	75	_	_ _ _
Quad Cities 2[d]	Exelon Generation Co., LLC	75	_	_ _
Quad Cities 2[d]	MidAmerica Energy Holdings	25	_ _	_ _
Susquehanna 1	PPL Susquehanna, LLC	90	_ _	_ _
Vermont Yankee	Entergy Nuclear Operations, Inc.	100	_ _[h]	_ _[h]
Vogtle 1	Oglethorpe Power Co.	30	_ _	_ _ _
Waterford 3	Entergy Louisiana, Inc.	100	_ _	_ _
Wolf Creek 1	Kansas City Power & Light Co.	47	_ _	_ _
Wolf Creek 1	Kansas Gas & Electric Co.	47	_	_ _
Yankee Rowe[e]	Yankee Atomic Electric Co.	100	_ _	_ _ _

Legend

+ means that fund balance/recent contributions were 0 to 25 percent more than benchmark.

++ means that fund balance/recent contributions were 26 to 50 percent more than benchmark.

+++ means that fund balance/recent contributions were 51 to 100 percent more than benchmark.

++++ means that fund balance/recent contributions were 101 percent or more than benchmark.

_ means that fund balance/recent contributions were 0.1 to 25 percent less than benchmark.

_ _ means that fund balance/recent contributions were 26 to 50 percent less than benchmark.

_ _ _ means that fund balance/recent contributions were 51 to 100 percent less than benchmark.

Source: GAO analysis.

[a]Owners' funds were selected to be screened under pessimistic assumptions based on our baseline results; namely, that the status of their trust funds was 0 to 100 percent above baseline benchmark on balances and/or contributions.

[b]See app. I for description of pessimistic assumptions.

[c]Adequacy of recent contributions is based on responses to our survey. The percentages are more, or less, than the benchmark, meaning the owner has contributed more, or less, on average for 1999 and 2000 (cost adjusted to 2000) than the annual average of the present value amounts required in each subsequent year until its plant is retired.

[d]Plant whose owners have applied for 20-year license renewals or are expected to apply by December 2003, as of August 20, 2003.

[e]Plant has permanently shut down.

[f]Plant's operating license extended for 20 years.

[g]Contributions data are not available.

[h]Includes balances and/or contributions from a previous owner's biennial report and/or responses to our survey.

Comments from the Nuclear Regulatory Commission

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 3, 2003

Mr. James E. Wells
Director, Natural Resources and Environment
United States General Accounting Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Wells:

I would like to thank you for the opportunity to review and submit comments on the draft of the General Accounting Office's (GAO's) report entitled "Nuclear Regulation - NRC Needs More Effective Analysis to Ensure Accumulation of Funds to Decommission Nuclear Power Plants." The United States Nuclear Regulatory Commission (NRC) appreciates the time and effort that you and your staff have taken to review this topic.

See comment 1.

GAO concludes that the NRC's analyses of funding levels of co-owners of a nuclear power plant are inconsistent with its internal guidance, the NRC does not have a method of determining whether licensees are accumulating funds at sufficient rates to pay for decommissioning, and the NRC needs to establish criteria for taking action when licensees are at unacceptable levels of funding assurance.

See comment 2.

The NRC disagrees with GAO's first two conclusions and believes that to establish criteria for taking action when licensees are at unacceptable funding levels is secondary to its primary concern which is to assure that licensees are accumulating funds at appropriate rates. Further, in NRC's view, it is questionable whether the development of criteria to address insufficient funding levels is warranted, given the unique set of circumstances and considerations that would apply to each licensee.

See comment 3.

Therefore, the NRC recommends that GAO state, in its report, that: (1) NRC's practice with respect to analyzing decommissioning funds where nuclear power plants have co-owners is consistent with its internal guidance; (2) the NRC has a methodology that is different from GAO's for assessing whether funds are being accumulated appropriately, and GAO's conclusions regarding sufficient accumulation of funds is based on GAO's methodology that has not been reviewed and accepted by the NRC; and (3) the NRC's practice is to review licensees who have not accumulated sufficient funds on a case-by-case basis due, in part, to the complexity and range of circumstances that may arise with any given licensee, particularly those that are subject to the jurisdiction of State regulators. Specific comments are provided on the three main GAO conclusions, as described below, and are elaborated on in greater detail in the enclosure.

See comment 4.

- First, the GAO report states that NRC's internal guidance requires NRC to separately assess the status of each co-owner's trust funds against each co-owner's contractual obligations with other co-owners to fund decommissioning. We do not agree that the guidance requires assessment against co-owners' contractual obligations. The NRC

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reviews the accumulated balances and planned future contributions of each co-owner in order to evaluate the total trust fund balance expected for each reactor. Where a nuclear power plant has multiple owners, it is the owners' collective responsibility to meet the funding requirements for the plant.

See comment 5.

- Second, while the GAO report suggests that the NRC use a "benchmark" amount of funds that owners should have accumulated by the end of year 2000 to determine if owners are "on track" to pay for eventual decommissioning, NRC regulations do not establish intermediate benchmarking levels, but rather establish the minimum balance that must be obtained at the permanent termination of operations. The NRC has always deferred to the State public utility commission, or other regulatory authority with rate making powers, to set rates to fund decommissioning trusts. The NRC determines whether there is reasonable assurance that adequate funds will be available for decommissioning by reviewing a licensee's current fund balance, its plan for future deposits, and its projected earnings, to the extent provided by NRC regulations, consistent with and in recognition of the significant role State regulatory authorities and FERC have in setting the rates at which licensees collect decommissioning funds.

See comment 6.

- Third, the NRC's practice is to deal with licensees who have not accumulated sufficient funds on a case-by-case basis due in part, to the complexity and range of circumstances that may arise with any given licensee, particularly those that are subject to the jurisdiction of State regulators.

The NRC will continue to evaluate its processes and policies associated with the decommissioning of power reactor facilities. The enclosed NRC comments are intended to provide a more comprehensive perspective related to the conclusions and recommendations contained in the draft GAO report.

Should you have any questions about these comments, please contact either Mr. William Dean at 301-415-1703 or Ms. Melinda Malloy at 301-415-1785, of my staff.

Sincerely,

William D. Travers
Executive Director for Operations

Enclosure: As stated

NRC Comments on the Draft General Accounting Office Report "Nuclear Regulation - NRC Needs More Effective Analysis to Ensure Accumulation of Funds to Decommission Nuclear Power Plants" (GAO-04-32)

1. **The GAO report states on page 4: "Although the collective status of the owners' decommissioning fund accounts has improved since our last report, some individual owners are not on track to accumulate sufficient funds for decommissioning."**

See comment 7.

The NRC disagrees with GAO's conclusion that some individual owners are not on track to accumulate sufficient funds for decommissioning because GAO's conclusion is based on GAO's methodology which is different from the NRC's and has not been reviewed and accepted by NRC.

See comment 8.

The NRC recommends that GAO state, in its report, that NRC has a different methodology than GAO for assessing whether an owner is "on track." The NRC's methodology with respect to licensees who are authorized to accumulate funds over time assesses the reasonableness of the collection schedules proffered by licensees by weighing several factors such as the current fund balance, the licensee's plan for future deposits, and the projected earnings to the extent provided by NRC regulations, consistent with and in recognition of the significant role State regulatory authorities and FERC have in setting the rates at which licensees collect decommissioning funds.

Now on p. 3.

2. **On page 5, the GAO report states: ". . . contrary to NRC's internal guidance, for the plants with more than one owner, NRC did not separately assess the status of each co-owner's trust funds against the co-owner's contractual obligation to fund decommissioning."**

See comment 9.

The NRC does not agree that its assessment of plants is contrary to NRC's internal guidance. The NRC review process for decommissioning trust fund assurance does, in fact, incorporate the information regarding each licensee's amortization schedule, where multiple owners per license exist, and where such information for each licensee has been submitted individually (in some cases, a lead licensee will report information for all co-owners). The phrase "for its share of the facility" as taken from page 11 of NUREG-1577, Rev. 1, "Standard Review Plan on Power Reactor Licensee Financial Qualifications and Decommissioning Funding Assurance," only reflects that an individual co-owner should report its own information (absent other arrangements for a lead licensee to report on behalf of the other co-owners), and is not obligated to provide information for other co-owners. The phrase does not indicate that the NRC must analyze each co-owner's decommissioning funds with regard to its private contractual obligations. The NRC does not separately assess the status of each co-owner's decommissioning funding against the co-owner's private contractual obligation to fund decommissioning.

Enclosure

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While the NRC recognizes that private contractual arrangements among co-owners exist, the NRC's primary concern is that on a plant basis, there are adequate funds available from the licensees of the plant on a collective or aggregate basis. The NRC reserves the right, in highly unusual situations where adequate protection of public health and safety would be compromised if such action were not taken, to consider imposing joint and several liability on co-owners for decommissioning funding when one or more co-owners have defaulted. The NRC's practice is consistent with this policy.

The NRC recommends that GAO revise its report to state that the staff's practice in analyzing decommissioning funding for plants with multiple owners is consistent with its internal guidance.

Now on p. 3.

3. **On page 6, the GAO report states: ". . . NRC has not established criteria for responding to any unacceptable levels of financial assurance. Accordingly, we are recommending that NRC develop and use an effective method for determining whether owners are accumulating funds at sufficient rates and establish criteria for responding to unacceptable levels of financial assurance."**

See comment 10.

The NRC disagrees with GAO's finding that the NRC has not developed and used a method of determining whether owner utilizing sinking funds are accumulating funds at sufficient rates. The NRC has a method which assesses the reasonableness of the collection schedule by weighing several factors. Therefore, the NRC recommends that GAO revise its report to state that the NRC has a method for determining whether owners are reasonably accumulating sufficient funds. If it is determined that unacceptable levels of financial assurance exist, the NRC will immediately seek licensees' plans to provide acceptable funding mechanisms, review those plans on a case-by-case basis in light of the specific circumstances involved, engage in discussions with relevant State regulators, and issue orders as necessary and appropriate. Beyond the general activities, the NRC has not established criteria for responding to unacceptable levels of financial assurance nor do we believe that such a criteria is worthwhile given the complexity and range of circumstances that may arise with any given licensee, particularly those who are subject to jurisdiction of State regulators.

Now on p. 7.

4. **On page 10, the GAO report includes a section entitled "Several Owners Are Not Accumulating Sufficient Funds for Decommissioning Their Plants."**

See comment 11.

The NRC analyzed a sample of licensees in 2001 to determine whether they were accumulating sufficient funds for decommissioning their plants. Based on the sample, the NRC did not find any owners who were not accumulating sufficient funds. The NRC recognizes that GAO's conclusions are based on GAO's own method of analysis, however, that method of analysis has not been accepted by the NRC.

See comment 12.

Therefore, the NRC recommends that GAO clarify its report to state that its conclusion that several owners are not accumulating sufficient funds is based on a GAO methodology or criteria that has not been accepted by the NRC. The NRC further recommends that GAO acknowledge in its report that there may be other acceptable methodologies or criteria to determine whether adequate funds are being collected that could yield different conclusions, particularly since there are many variables that reasonably can be incorporated into a given methodology.

Now on p. 14.

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5. **On page 16, the GAO report states: "They [NRC official] also stated that NRC's regulations do not prohibit each co-owner from being held responsible for decommissioning costs even if these costs are more than the co-owner's individual ownership share. However, assessing the adequacy of decommissioning costs on plant-wide basis is not consistent with the industry view, held by most plant owners, that each co-owner should be limited to its pro rata share of decommissioning expenses. . . . "**

See comment 13.

The NRC recognizes the existence of licensee arrangements via private contracts where licensees are responsible for decommissioning costs in proportion to their ownership interests, and does not object to these private contractual arrangements. However, the NRC reserves the right, in highly unusual situations where adequate protection of public health and safety would be compromised if such action were not taken, to consider imposing joint and several liability on co-owners for decommissioning funding when one or more co-owners have defaulted. Therefore, the GAO should revise its report to clarify that while there are a variety of industry practices and views, the NRC's primary intent is assuring the collective accumulation of decommissioning funds.

The following are GAO's comments on NRC's letter dated October 3, 2003.

GAO Comments

1. Rather than concluding that NRC does not have a method, we stated that the agency's analysis was not effective in identifying owners who might be at risk of accumulating insufficient funds to pay for decommissioning. For example, NRC relied on the owners' future funding plans to make up any shortfalls without verifying whether the plans are consistent with the owners' recent contributions. See also our response in the Agency Comments and Our Evaluation section on page 16.

2. We agree that NRC should be primarily concerned with ensuring that owners of nuclear power plants will have sufficient funds for decommissioning. However, we believe that NRC should take a proactive, rather than reactive, approach to providing owners and the public with a more complete understanding of NRC's expectations as to how they will hold owners who are not accumulating sufficient funds accountable. As discussed in the report, the lack of any specific criteria for acting on owners' decommissioning financial reports contrasts with NRC's practices in overseeing safety issues at nuclear plants, where the agency uses an "Action Matrix" that provides for a range of actions commensurate with the significance of safety inspection findings and performance indicators. Without similar criteria in its oversight of decommissioning funding assurance, NRC will not have a logical, coherent, consistent, and predictable plan of action if and when it encounters owners whose plants have inadequate financial assurance. See also our response in the Agency Comments and Our Evaluation section on page 16.

3. See our responses to comments 5, 6, and 9 in this appendix.

4. See our responses to comment 9.

5. We agree that current NRC regulations do not establish intermediate benchmarking levels, but rather establish the minimum balance that must be obtained when plants are retired. We also agree that the state regulatory authorities and Federal Energy Regulatory Commission play a role. However, we believe that NRC should take a more proactive approach in developing an effective method for ensuring that sufficient funds will be available for decommissioning. For example, a common expected rate of return could be used to project the earnings of each

owner's trust fund. NRC's current method allows the owners to use up to 2 percent (real) or another rate if approved by its state regulator. As we stated in our report, one state regulator approved owners of the same plant to use widely varying rates of return to project earnings on their trust fund investments. Other factors being equal, the owner using the higher rate would need to collect fewer funds than the owner using a lower rate of return. While the actual rate the owners will earn on their funds could be higher or lower, NRC accepted the state regulator-approved rates without assessing whether they were consistent with market expectations.

In another example, in its 2001 biennial report, one owner using NRC's 2 percent rate of return estimated that the amount of funds needed for decommissioning under NRC's regulations would be insufficient at five of its nuclear power plants. Therefore, the owner provided additional assurance in the form of a parent guarantee. However, the owner sought and subsequently received approval from its state regulator to use a higher real rate of return. After receiving the approval, the owner withdrew its parent guarantee since under the higher rate, the projected trust funds were sufficient to cover estimated decommissioning costs. We believe that by being more proactive, and not simply deferring to others, the NRC can develop a more effective and consistent method and better achieve its primary concern of ensuring that owners are accumulating funds at sufficient rates.

6. We found no evidence during our review that NRC has ever determined that an owner is not accumulating sufficient funds. Therefore, without any experience that its "practice" has been applied, we believe that without clear criteria, NRC will not have a logical, coherent, consistent, and predictable plan of action if and when it encounters owners whose plants have inadequate financial assurance. Accordingly, we are recommending that NRC establish criteria for responding to unacceptable levels of financial assurance.

7. We agree that our method is different from that used by NRC. Our draft discussed and reviewed NRC's analysis. Based on our review, we concluded that NRC's analysis was not effective in identifying owners who might be at risk of accumulating insufficient funds to pay for eventual decommissioning. For example, NRC relied on the owners' future funding plans, or on rate-setting authority decisions, in concluding that the owners were on track to fully fund decommissioning. However, we found some owners' actual

contributions in 2001 were much less than what they stated in their 2001 biennial reports to NRC that they planned to contribute. For example, one owner contributed about $1.5 million (or 39 percent) less than the amount it told NRC that it planned to contribute. Moreover, using actual contributions the owners had recently made to their trust funds, we identified several owners that are at risk of accumulating insufficient funds to pay for eventual decommissioning.

8. We do not believe any changes are needed.

9. We agree, and the our draft report stated, that NRC does not separately assess the status of each co-owner's decommissioning funding against the co-owner's private contractual obligation to fund decommissioning. The NRC guidance states: "Some licensees are part owners of power reactors. In such cases, the [NRC] reviewer should evaluate separately each licensee's [co-owner's] *amortization* schedule [i.e., decommissioning funding] for its share of the facility, unless the lead licensee has agreed to coordinate funding documentation and reporting for all co-owners." Nonetheless, we revised the report to remove any inferences that NRC's practice is inconsistent with its internal guidance. Notwithstanding NRC's characterization of its practice, we believe that both the guidance and NRC's actions do not go far enough. For example, the guidance allows for an exception when the lead licensee agrees to coordinate documentation and reporting. More importantly, the critical issue is that NRC should do more to develop an effective method for assessing the adequacy of nuclear power plant owner's trust funds for decommissioning. Under NRC's current method, it combines the trust funds for all co-owners of a nuclear plant and then assesses the adequacy of decommissioning funds on a plant-wide basis. However, as our analysis indicates, combining the trust funds of several owners can produce misleading results because those co-owners with more than sufficient funds can appear to balance out those with less than sufficient funds. In addition, as a practical matter, owners have contractual agreements to pay for their share of decommissioning, and the trust funds are generally not transferable among owners. Unless NRC separately evaluates the adequacy of each co-owners' decommissioning trust fund, the agency's existing process would appear to require some co-owners to pay more than their fair share of decommissioning costs. We believe this would be inconsistent with NRC's stated policy of generally not looking to one co-owner to bail out another.

10. Rather than state that NRC has not developed and used a method, we found that the agency's method was not effective in identifying owners who might be at risk of accumulating insufficient funds to pay for decommissioning. For example, we identified several limitations in NRC's method, including the agency's practice of combining the trust funds for all the co-owners of a nuclear plant and then assessing whether the combined value of the trust funds is sufficient. We believe that this practice can produce misleading results because those co-owners with more than sufficient funds can appear to balance out those with less than sufficient funds.

    In addition, we agree that NRC has not established criteria for taking action when it finds cases of unacceptable levels of financial assurance. According to NRC officials we spoke to, NRC has never identified an owner with unacceptable levels of financial assurance. Moreover, the general activities that NRC stated above are not included in its internal guidance for reviewing the owners' biennial reports. We believe that NRC should take a more proactive approach to providing owners and the public with a more complete understanding of NRC's expectations as to how they will hold owners who are not accumulating sufficient funds accountable. We believe having established criteria for taking action when it is determined that unacceptable levels of financial assurance exist will better prepare NRC to make this determination. Furthermore, having such criteria would not only increase public confidence that NRC has a plan to take action to ensure sufficient funds will be available for decommissioning but also would make its determination of inadequacy more transparent to owners.

11. As indicated in our draft report, we reviewed NRC's analysis of the owners' 2001 biennial reports. Our review clearly points out that the agency's method has limitations that reduce its effectiveness. For example, NRC relied on the owners' future funding plans to make up any shortfalls without verifying whether those plans are consistent with the owners' recent contributions. We found that some owners' actual contributions in 2001 were much less than what they stated in their 2001 biennial reports to NRC that they planned to contribute. For example, one owner contributed about $1.5 million (or 39 percent) less than the amount they told NRC that they planned to contribute. In addition, based on our analysis using the actual contributions the owners recently made to their trust funds, we found that 28 owners with ownership shares in 44 plants contributed less than the amounts we estimate they will need to contribute over the remaining life of their

plants to meet their decommissioning obligations. Accordingly, we believe that our recommendation to NRC to develop an effective method is clearly warranted to ensure that all owners are accumulating funds at sufficient rates. See also our response to comment 12.

12. As stated in our draft, our conclusions are based on a method that uses a benchmark to assess the adequacy of each nuclear plant owner's decommissioning trust fund. In addition, our draft stated that this benchmark is not the only way an owner could accrue enough funds to pay future decommissioning costs. Still, we believe that our benchmark is useful for assessing the status of the owners' decommissioning trust funds because it (1) provides a common standard for comparisons among owners, (2) embodies the principle of economic efficiency in that the price of a product (i.e., electricity) should, if possible, equal all of its costs—current and accrued, and (3) provides for transparency in that it assumes that current and future users pay the same decommissioning fees, in constant present-value terms.

13. As we stated in our draft, NRC stated that it will not impose decommissioning costs on co-owners in a manner inconsistent with their agreed-upon shares, except in highly unusual circumstances when required by public health and safety considerations and that it would not seek more than the *pro rata* shares from co-owners with *de minimis* ownership. Nevertheless, unless NRC separately evaluates the adequacy of each co-owners' decommissioning trust fund, the agency's existing process would appear to require some co-owners to pay more than their fair share of decommissioning costs. We believe this would be inconsistent with NRC's stated policy of generally not looking to one co-owner to bail out another one.

Appendix IV

GAO Contact and Staff Acknowledgments

GAO Contact

Tim Guinane (202) 512-4939

Acknowledgments

In addition, Ronald La Due Lake, Carolyn McGowan, Cynthia Norris, Michael Sagalow, Barbara Timmerman, Daniel G. Williams, and Dwayne Weigel made key contributions to this report.

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United States General Accounting Office

GAO

Report to Congressional Requesters

May 2004

NUCLEAR REGULATION

NRC's Liability Insurance Requirements for Nuclear Power Plants Owned by Limited Liability Companies

GAO

Accountability * Integrity * Reliability

GAO-04-654

May 2004

GAO Accountability • Integrity • Reliability

Highlights

Highlights of GAO-04-654, a report to congressional requesters

NUCLEAR REGULATION

NRC's Liability Insurance Requirements for Nuclear Power Plants Owned by Limited Liability Companies

Why GAO Did This Study

An accident at one the nation's commercial nuclear power plants could result in human health and environmental damages. To ensure that funds would be available to settle liability claims in such cases, the Price-Anderson Act requires licensees for these plants to have primary insurance—currently $300 million per site. The act also requires secondary coverage in the form of retrospective premiums to be contributed by all licensees to cover claims that exceed primary insurance. If these premiums are needed, each licensee's payments are limited to $10 million per year and $95.8 million in total for each of its plants. In recent years, limited liability companies have increasingly become licensees of nuclear power plants, raising concerns about whether these companies—by shielding their parent corporations' assets—will have the financial resources to pay their retrospective premiums.

GAO was asked to determine (1) the extent to which limited liability companies are the licensees for U.S. commercial nuclear power plants, (2) the Nuclear Regulatory Commission's (NRC) requirements and procedures for ensuring that licensees of nuclear power plants comply with the Price-Anderson Act's liability requirements, and (3) whether and how these procedures differ for licensees that are limited liability companies.

www.gao.gov/cgi-bin/getrpt?GAO-04-654.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells at 202-512-3841.

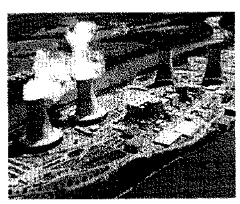
What GAO Found

Of the 103 operating nuclear power plants, 31 are owned by 11 limited liability companies. Three energy corporations—Exelon, Entergy, and the Constellation Energy Group—are the parent companies for eight of these limited liability companies. These 8 subsidiaries are the licensees or co-licensees for 27 of the 31 plants.

NRC requires all licensees for nuclear power plants to show proof that they have the primary and secondary insurance coverage mandated by the Price-Anderson Act. Licensees obtain their primary insurance through American Nuclear Insurers. Licensees also sign an agreement with NRC to keep the insurance in effect. American Nuclear Insurers also has a contractual agreement with each of the licensees to collect the retrospective premiums if these payments become necessary. A certified copy of this agreement, which is called a bond for payment of retrospective premiums, is provided to NRC as proof of secondary insurance. It obligates the licensee to pay the retrospective premiums to American Nuclear Insurers.

NRC does not treat limited liability companies differently than other licensees with respect to the Price-Anderson Act's insurance requirements. Like other licensees, limited liability companies must show proof of both primary and secondary insurance coverage. American Nuclear Insurers also requires limited liability companies to provide a letter of guarantee from their parent or other affiliated companies with sufficient assets to pay the retrospective premiums. These letters state that the parent or affiliated companies are responsible for paying the retrospective premiums if the limited liability company does not. American Nuclear Insurers informs NRC it has received these letters. In light of the increasing number of plants owned by limited liability companies, NRC is studying its existing regulations and expects to report on its findings by the end of summer 2004.

In commenting on a draft of this report, NRC stated that it accurately reflects the present insurance system for nuclear power plants.



Source: NRC.

Aerial view of the Three Mile Island Nuclear Station in Pennsylvania, where the most serious accident at a U.S. nuclear power plant occurred in March 1979, resulting in $70 million in liability claims.

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GAO
Accountability * Integrity * Reliability

United States General Accounting Office
Washington, D.C. 20548

May 28, 2004

Congressional Requesters

An accident at one of the nation's 103[1] operating commercial nuclear power plants could result in human health and environmental damages. The Price-Anderson Act was enacted in 1957 to ensure that funds would be available for at least a portion of the damages suffered by the public in the event of an incident at a U.S. nuclear power plant. The act requires each licensee of a nuclear plant to have primary insurance coverage equal to the maximum amount of liability insurance available from private sources—currently $300 million—to settle any such claims against it. In the event of an accident at any plant where liability claims exceed the $300 million primary insurance coverage, the act also requires licensees for all plants to pay retrospective premiums (also referred to as secondary insurance). Under current U.S. Nuclear Regulatory Commission (NRC) regulations, these payments could amount to a maximum of $95.8 million for each of a licensee's plants per incident. If claims for an incident exceed this approximately $10 billion currently available in primary insurance and retrospective premiums, NRC may request additional funds from the Congress. To operate a nuclear power plant, the owner must obtain a license from NRC and meet its regulatory requirements, including those for liability insurance established under the Price-Anderson Act.

A major aspect of the deregulation or restructuring of the U.S. electricity industry in the 1990s was the separation of electricity generation from transmission and distribution. Utilities could create separate entities or subsidiaries to operate their generation facilities, including nuclear power plants, or could sell them off to other companies. Energy holding companies bought some of the generation facilities, sometimes placing them under subsidiaries. The limited liability company also emerged in the 1990s as a new type of company structure in the United States. These companies have characteristics of both a partnership and a corporation. Like a partnership, the profits are passed through and taxable to the owners, known as members; like a corporation, it is a separate and distinct legal entity and its owners are insulated from personal liability for its debts and liabilities.

[1]Although 104 commercial nuclear power plants are licensed to operate in the United States, 1 plant, Browns Ferry Unit 1, was shut down in 1985 and remains idle.

You asked us to determine (1) the extent to which limited liability companies are the licensees for U.S. commercial nuclear power plants, (2) NRC's requirements and procedures for ensuring that licensees of nuclear power plants comply with the Price-Anderson Act's liability requirements, and (3) whether and how these procedures differ for licensees that are limited liability companies. To respond to your request, we reviewed applicable sections of the Price-Anderson Act and NRC's implementing regulations and written procedures. We also held discussions with and obtained information from responsible NRC officials and representatives of American Nuclear Insurers, which is a joint underwriting association of 50 insurance companies that provides insurance coverage to the nuclear power plants. These are property/casualty insurance companies licensed to do business in at least one of the states or territories of the United States. We performed our work between April 2003 and April 2004 in accordance with generally accepted government auditing standards.

Results in Brief

Thirty-one of the 103 operating commercial nuclear power plants nationwide are licensed to limited liability companies. Four of the 31 plants are licensed jointly to two limited liability companies. A total of 11 limited liability companies are licensed to own nuclear power plants. One—the Exelon Generation Company, LLC—is the licensee for 12 plants and co-licensee for 4 plants. The 10 other limited liability companies are the licensees or co-licensees for one to five plants. Three energy corporations—Exelon, Entergy, and the Constellation Energy Group—are the parent companies for eight of the limited liability companies. These eight subsidiaries are the licensees or co-licensees for 27 of the 31 plants.

NRC's procedures for ensuring that licensees comply with Price-Anderson Act liability insurance provisions include requirements that licensees provide proof of primary and secondary insurance coverage. NRC requires each licensee to show proof that it has liability insurance that includes the $300 million of primary insurance coverage per site required by the Price-Anderson Act. NRC and the licensee also sign an indemnity agreement that requires the licensee to maintain an insurance policy in this amount. This agreement is in effect as long as the owner is licensed to operate the plant. NRC relies on American Nuclear Insurers—the joint underwriting association that provides insurance for U.S. nuclear power plants—to send NRC the annual endorsements documenting proof of insurance after the licensees have paid their annual premiums. In addition to the primary insurance coverage, licensees must also show proof of secondary insurance to NRC. This secondary insurance is in the form of retrospective

premiums that, in the event of a nuclear incident causing damages exceeding $300 million, would be collected from each nuclear power plant licensee at a rate of up to $10 million per year and up to a maximum of $95.8 million per incident for each nuclear power plant. Typically, each licensee signs a bond for payment of retrospective premiums as proof of the secondary insurance and furnishes NRC with a certified copy. This bond is a contractual agreement between the licensee and American Nuclear Insurers that obligates the licensee to pay American Nuclear Insurers the retrospective premiums. In the event that claims exhaust primary coverage, American Nuclear Insurers would collect the retrospective premiums. If a licensee did not pay its share of these retrospective premiums, American Nuclear Insurers would, under its agreement with the licensees, pay up to $30 million of the premiums in 1 year and attempt to collect this amount later from the licensees.

NRC does not treat limited liability companies differently than other licensees of nuclear power plants with respect to Price-Anderson Act liability requirements. All licensees follow the same regulations and procedures regardless of whether they are limited liability companies. Like other licensees, limited liability companies are required to show that they are maintaining $300 million in primary insurance coverage, and they provide NRC a copy of the bond for payment of retrospective premiums. While NRC does not conduct in-depth financial reviews specifically to determine licensees' ability to pay retrospective premiums, when a licensee applies for a license or when the license is transferred, NRC reviews the licensee's financial ability to safely operate the plant and to contribute decommissioning funds for the future retirement of the plant. According to NRC officials, if licensees have the financial resources to cover these two expenses, they are likely to be capable of paying their retrospective premiums. American Nuclear Insurers goes further than NRC and requires limited liability companies to provide a letter of guarantee from their parent or other affiliated companies with sufficient assets to cover the retrospective premiums. These letters state that the parent or an affiliated company is responsible for paying the retrospective premiums if the limited liability company does not. American Nuclear Insurers informs NRC that it has received these letters of guarantee. Recognizing that limited liability companies are becoming more prevalent as owners of nuclear power plants, NRC is examining whether it needs to revise any of its regulations and procedures for these companies. NRC estimates the study will be completed by the end of summer 2004.

In commenting on a draft of this report, NRC stated that it accurately reflects the present insurance system for nuclear power plants.

Background

The Atomic Energy Act of 1954 authorized a comprehensive regulatory program to permit private industry to develop and apply atomic energy for peaceful uses, such as generating electricity from privately owned nuclear power plants. Soon thereafter, government and industry experts identified a major impediment to accomplishing the act's objective: the potential for payment of damages resulting from a nuclear accident and the lack of adequate available insurance. Unwilling to risk huge financial liability, private companies viewed even the remote specter of a serious accident as a roadblock to their participating in the development and use of nuclear power.[2] In addition, congressional concern developed over ensuring adequate financial protection to the public because the public had no assurance that it would receive compensation for personal injury or property damages from the liable party in event of a serious accident. Faced with these concerns, the Congress enacted the Price-Anderson Act in September 1957. The Price-Anderson Act has two underlying objectives: (1) to establish a mechanism for compensating the public for personal injury or property damage in the event of a nuclear accident and (2) to encourage the development of nuclear power.

To provide financial protection, the Price-Anderson Act requires commercial nuclear reactors to be insured to the maximum level of primary insurance available from private insurers. To implement this provision, NRC periodically revises its regulations to require licensees of nuclear reactors to increase their coverage level as the private insurance market increases the maximum level of primary insurance that it is willing to offer. For example, in January 2003, NRC increased the required coverage from $200 million to the current $300 million, when American Nuclear Insurers informed NRC that $300 million per site in coverage was now available in its insurance pool.

In 1975, the Price-Anderson Act was amended to require licensees to pay a pro-rated share of the damages in excess of the primary insurance amount.

[2]NRC's regulations define a nuclear incident as any occurrence that causes bodily injury, sickness, disease, or death or loss of or damage to property or for loss of the use of property arising out of or resulting from the radioactive, toxic, explosive, or other hazardous properties of the source, special nuclear or byproduct material.

Under this amendment, each licensee would pay up to $5 million in retrospective premiums per facility it owned per incident if a nuclear accident resulted in damages exceeding the amount of primary insurance coverage. In 1988, the act was further amended to increase the maximum retrospective premium to $63 million per reactor per incident to be adjusted by NRC for inflation. The amendment also limited the maximum annual retrospective premium per reactor to $10 million. Under the act, NRC is to adjust the maximum amount of retrospective premiums every 5 years using the aggregate change in the Consumer Price Index for urban consumers. In August 2003, NRC set the current maximum retrospective payment at $95.8 million per reactor per incident. With 103 operating nuclear power plants, this secondary insurance pool would total about $10 billion.[3]

The Price-Anderson Act also provides a process to deal with incidents in which the damages exceed the primary and secondary insurance coverage. Under the act, NRC shall survey the causes and extent of the damage and submit a report on the results to, among others, the Congress and the courts. The courts must determine whether public liability exceeds the liability limits available in the primary insurance and secondary retrospective premiums. Then the President would submit to the Congress an estimate of the financial extent of damages, recommendations for additional sources of funds, and one or more compensation plans for full and prompt compensation for all valid claims. In addition, NRC can request the Congress to appropriate funds. The most serious incident at a U.S. nuclear power plant took place in 1979 at the Three Mile Island Nuclear Station in Pennsylvania. That incident has resulted in $70 million in liability claims.

NRC's regulatory activities include licensing nuclear reactors and overseeing their safe operation. Licensees must meet NRC regulations to obtain and retain their license to operate a nuclear facility. NRC carries out reviews of financial qualifications of reactor licensees when they apply for a license or if the license is transferred, including requiring applicants to demonstrate that they possess or have reasonable assurance of obtaining funds necessary to cover estimated operating costs for the period of the license. NRC does not systematically review its licensees' financial qualifications once it has issued the license unless it has reason to believe

[3]NRC regulations also require licensees to maintain $1 billion in on-site property damage insurance to provide funds to deal with cleanup of the reactor site after an accident.

this is necessary. In addition, NRC performs inspections to verify that a licensee's activities are properly conducted to ensure safe operations in accordance with NRC's regulations. NRC can issue sanctions to licensees who violate its regulations. These sanctions include notices of violation; civil penalties of up to $100,000 per violation per day; and orders that may modify, suspend, or revoke a license.

Limited Liability Companies Are Licensees for 31 of the 103 Operating Commercial Nuclear Power Plants in the United States

Thirty-one commercial nuclear power plants nationwide are licensed to limited liability companies. In total, 11 limited liability companies are licensed to own nuclear power plants. Three energy corporations—Exelon, Entergy, and the Constellation Energy Group—are the parent companies for 8 of these limited liability companies. These eight subsidiaries are licensed or co-licensed to operate 27 of the 31 plants. The two subsidiaries of the Exelon Corporation are the licensees for 15 plants and the co-licensees for 4 others. Constellation Energy Group, Inc., and Entergy Corporation are the parent companies of limited liability companies that are licensees for four nuclear power plants each. (See table 1.)

Table 1: Limited Liability Companies Licensed to Operate Nuclear Power Plants and Their Parent Companies

Limited liability company	Parent company	Number of plants owned or co-owned
Exelon Generation Company, LLC	Exelon Corporation	12
AmerGen Energy Company, LLC	Exelon Corporation	3
Exelon Generation Company, LLC; PSEG Nuclear, LLC	Exelon Corporation; Public Service Enterprise Group, Incorporated	4
PSEG Nuclear, LLC	Public Service Enterprise Group, Incorporated	1
Calvert Cliffs Nuclear Power Plant, LLC	Constellation Energy Group, Inc.	2
Nine Mile Point Nuclear Station, LLC	Constellation Energy Group, Inc.	2
Entergy Nuclear Indian Point 2, LLC	Entergy Corporation	1
Entergy Nuclear Indian Point 3, LLC	Entergy Corporation	1
Entergy Nuclear FitzPatrick, LLC	Entergy Corporation	1
Entergy Nuclear Vermont Yankee, LLC	Entergy Corporation	1
FPL Energy Seabrook, LLC	FPL Group, Inc.	1
PPL Susquehanna, LLC	Pennsylvania Power and Light Company	2

Source: GAO survey of NRC project managers.

Of all the limited liability companies, Exelon Generation Company, LLC, has the largest number of plants. It is the licensee for 12 plants and co-licensee with PSEG Nuclear, LLC, for 4 other plants. For these 4 plants, Exelon Generation owns 43 percent of Salem Nuclear Generating Stations 1 and 2 and 50 percent of Peach Bottom Atomic Power Stations 2 and 3. (App. I lists all the licensees and their nuclear power plants.)

NRC Has Specific Requirements and Procedures to Ensure That All Licensees Comply with the Price-Anderson Act's Liability Provisions

NRC requires licensees of nuclear power plants to comply with the Price-Anderson Act's liability insurance provisions by maintaining the necessary primary and secondary insurance coverage. First, NRC ensures that licensees comply with the primary insurance coverage requirement by requiring them to submit proof of coverage in the amount of $300 million. Second, NRC ensures compliance with the requirement for secondary coverage by accepting the certified copy of the licensee's bond for payment of retrospective premiums.

All the nuclear power plant licensees purchase their primary insurance from American Nuclear Insurers. American Nuclear Insurers sends NRC annual endorsements documenting proof of primary insurance after the licensees have paid their annual premiums. NRC and each licensee also sign an indemnity agreement, stating that the licensee will maintain an insurance policy in the required amount. This agreement, which is in effect as long as the owner is licensed to operate the plant, guarantees reimbursement of liability claims against the licensee in the event of a nuclear incident through the liability insurance. The agency can suspend or revoke the license if a licensee does not maintain the insurance, but according to an NRC official, no licensee has ever failed to pay its annual primary insurance premium and American Nuclear Insurers would notify NRC if a licensee failed to pay.[4]

As proof of their secondary insurance coverage, licensees must provide evidence that they are maintaining a guarantee of payment of retrospective premiums. Under NRC regulations, the licensee must provide NRC with evidence that it maintains one of the following six types of guarantees: (1) surety bond, (2) letter of credit, (3) revolving credit/term loan arrangement, (4) maintenance of escrow deposits of government securities, (5) annual

[4]The average annual premium for a single nuclear power plant at a site is about $400,000. The premium for a second or third plant at the same site is discounted because the maximum amount of primary insurance for a multi-plant site is $300 million.

certified financial statement showing either that a cash flow can be generated and would be available for payment of retrospective premiums within 3 months after submission of the statement or a cash reserve or combination of these, or (6) such other type of guarantee as may be approved by the Commission.

Before the late 1990s, the licensees provided financial statements to NRC as evidence of their ability to pay retrospective premiums.[5] According to NRC officials, in the late 1990s, Entergy asked NRC to accept the bond for payment of retrospective premiums that it had with American Nuclear Insurers as complying with the sixth option under NRC's regulations: such other type of guarantee as may be approved by the Commission. After reviewing and agreeing to Entergy's request, NRC decided to accept the bond from all the licensees as meeting NRC's requirements. NRC officials told us that they did not document this decision with Commission papers or incorporate it into the regulations because they did not view this as necessary under the regulations.

The bond for payment of retrospective premiums is a contractual agreement between the licensee and American Nuclear Insurers that obligates the licensee to pay American Nuclear Insurers the retrospective premiums. Each licensee signs this bond and furnishes NRC with a certified copy. In the event that claims exhaust primary coverage, American Nuclear Insurers would collect the retrospective premiums. If a licensee were not to pay its share of these retrospective premiums, American Nuclear Insurers would, under its agreement with the licensees, pay for up to three defaults or up to $30 million in 1 year of the premiums and attempt to collect this amount later from the defaulting licensees. According to an American Nuclear Insurers official, any additional defaults would reduce the amount available for retrospective payments. An American Nuclear Insurers official told us that his organization believes that the bond for payment of retrospective premiums is legally binding and obligates the licensee to pay the premium. Under NRC regulations, if a licensee fails to pay the assessed deferred premium, NRC reserves the right to pay those premiums on behalf of the licensee and recover the amount of such premiums from the licensee.

[5]Fifteen licensees continue to provide financial statements to NRC.

NRC Treats Limited Liability Companies the Same as Other Licensees, but the Insurance Industry Has Added Important Requirements for These Companies

NRC applies the same rules to limited liability companies that it does to other licensees of nuclear power plants with respect to liability requirements under the Price-Anderson Act.

All licensees must meet the same requirements regardless of whether they are limited liability companies. American Nuclear Insurers applies an additional requirement for limited liability companies with respect to secondary insurance coverage in order to ensure that they have sufficient assets to pay retrospective premiums. Given the growing number of nuclear power plants licensed to limited liability companies, NRC is examining the need to revise its procedures and regulations for such companies.

NRC requires all licensees of nuclear power plants to follow the same regulations and procedures. Limited liability companies, like other licensees, are required to show that they are maintaining the $300 million in primary insurance coverage and provide NRC a copy of the bond for payment of retrospective premiums or other approved evidence of guarantee of retrospective premium payments. According to NRC officials, all its licensees, including those that are limited liability companies, have sufficient assets to cover the retrospective premiums. While NRC does not conduct in-depth financial reviews specifically to determine licensees' ability to pay retrospective premiums, it reviews the licensees' financial ability to safely operate their plants and to contribute decommissioning funds for the future retirement of the plants. According to NRC officials, if licensees have the financial resources to cover these two larger expenses, they are likely to be capable of paying their retrospective premiums.

American Nuclear Insurers goes further than NRC and requires licensees that are limited liability companies to provide a letter of guarantee from their parent or other affiliated companies with sufficient assets to cover the retrospective premiums. An American Nuclear Insurers official stated that American Nuclear Insurers obtains these letters as a matter of good business practice. These letters state that the parent or an affiliated company is responsible for paying the retrospective premiums if the limited liability company does not. If the parent company or other affiliated company of a limited liability company does not provide a letter of guarantee, American Nuclear Insurers could refuse to issue the bond for payment of retrospective premiums and the company would have to have another means to show NRC proof of secondary insurance. American Nuclear Insurers informs NRC that it has received these letters of

guarantee. The official also told us that American Nuclear Insurers believes that the letters from the parent companies or other affiliated companies of the limited liability company licensed by NRC are valid and legally enforceable contracts.

NRC officials told us that they were not aware of any problems caused by limited liability companies owning nuclear power plants and that NRC currently does not regard limited liability companies' ownership of nuclear power plants as a concern. However, because these companies are becoming more prevalent as owners of nuclear power plants, NRC is examining whether it needs to revise any of its regulations or procedures for these licensees. NRC estimates that it will complete its study by the end of summer 2004.

Agency Comments

We provided a draft of this report to NRC for review and comment. In its written comments (see app. II), NRC stated that it believes the report accurately reflects the present insurance system for nuclear power plants. NRC said that we correctly conclude that the agency does not treat limited liability companies differently than other licensees with respect to Price-Anderson's insurance requirements. NRC also stated that we are correct in noting that it is not aware of any problems caused by limited liability companies owning nuclear power plants and that NRC currently does not regard limited liability companies' ownership of nuclear power plants as a concern. In addition, NRC commented that we agree with the agency's conclusion that all its reactor licensees have sufficient assets that they are likely to be able to pay the retrospective premiums. With respect to this last comment, the report does not take a position on the licensees' ability to pay the retrospective premiums. We did not evaluate the sufficiency of the individual licensees' assets to make these payments. Instead, we reviewed NRC's and the American Nuclear Insurers' requirements and procedures for retrospective premiums.

Scope and Methodology

We performed our review at NRC headquarters in Washington, D.C. We reviewed statutes, regulations, and appropriate guidance as well as interviewed agency officials to determine the relevant statutory framework of the Price-Anderson Act. To determine the number of nuclear power plant licensees that are limited liability companies, we surveyed, through electronic mail, all the NRC project managers responsible for maintaining nuclear power plant licenses. We asked them to provide data on the

licensees, including the licensee's name and whether it was a limited liability company. If it was a limited liability company, we asked when the license was transferred to the limited liability company and who is the parent company of the limited liability company. We received responses for all 103 nuclear power plants currently licensed to operate. We analyzed the results of the survey responses. We verified the reliability of the data from a random sample of project managers by requesting copies of the power plant licenses and then comparing the power plant licenses to the data provided by the project managers. The data agreed in all cases. We concluded that the data were reliable enough for the purposes of this report.

To determine NRC's requirements for ensuring that licensees of nuclear power plants comply with the Price-Anderson Act's liability requirements, we reviewed relevant statutes and NRC regulations and interviewed NRC officials responsible for ensuring that licensees have primary and secondary insurance coverage. We also spoke with American Nuclear Insurers officials responsible for issuing the insurance coverage to nuclear power plant licensees, and we reviewed relevant documents associated with the insurance. To determine whether and how these procedures differ for licensees that are limited liability companies, we reviewed relevant documents, including NRC regulations, and interviewed NRC officials responsible for ensuring licensee compliance with Price-Anderson Act requirements.

As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days from the date of this letter. We will then send copies to interested congressional committees; the Commissioners, Nuclear Regulatory Commission; the Director, Office of Management and Budget; and other interested parties. We will make copies available to others on request. In addition, the report will be available at no charge on GAO's Web site at http://www.gao.gov.

If you or your staff have any questions about this report, I can be reached at (202) 512-3841. Major contributors to this report include Ray Smith, Ilene Pollack, and Amy Webbink. John Delicath and Judy Pagano also contributed to this report.

Jim Wells

Jim Wells
Director, Natural Resources
and Environment

List of Congressional Requesters

The Honorable Hillary Rodham Clinton
The Honorable James M. Jeffords
The Honorable Harry Reid
United States Senate

Appendix I

Nuclear Power Plant Ownership

	Plant	Licensed to own	LLC	License transfer date	LLC parent company
1	Arkansas Nuclear One 1	Entergy Arkansas, Inc.	No		
2	Arkansas Nuclear One 2	Entergy Arkansas, Inc.	No		
3	Arnold (Duane) Energy Center	Interstate Power and Light	No		
		Central Iowa Power Cooperative	No		
		Corn Belt Power Cooperative	No		
4	Beaver Valley Power Station 1	Pennsylvania Power Company	No		
		Ohio Edison Company	No		
		FirstEnergy Nuclear Operating Company	No		
5	Beaver Valley Power Station 2	Pennsylvania Power Company	No		
		Ohio Edison Company	No		
		Cleveland Electric Illuminating Company	No		
		Toledo Edison Company	No		
		FirstEnergy Nuclear Operating Company	No		
6	Braidwood Station 1	Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
7	Braidwood Station 2	Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
8	Browns Ferry Nuclear Power Station 1	Tennessee Valley Authority	No		
9	Browns Ferry Nuclear Power Station 2	Tennessee Valley Authority	No		
10	Browns Ferry Nuclear Power Station 3	Tennessee Valley Authority	No		
11	Brunswick Steam Electric Plant 1	Carolina Power & Light Co.	No		
		North Carolina Eastern Municipal Power Agency	No		
12	Brunswick Steam Electric Plant 2	Carolina Power & Light Co.	No		
		North Carolina Eastern Municipal Power Agency	No		
13	Byron Station 1	Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
14	Byron Station 2	Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
15	Callaway Plant	Union Electric Company	No		
16	Calvert Cliffs Nuclear Power Plant 1	Calvert Cliffs Nuclear Power Plant, LLC	Yes	6/19/2001	Constellation Energy Group, Inc.

(Continued From Previous Page)

	Plant	Licensed to own	LLC	License transfer date	LLC parent company
17	Calvert Cliffs Nuclear Power Plant 2	Calvert Cliffs Nuclear Power Plant, LLC	Yes	6/19/2001	Constellation Energy Group, Inc.
18	Catawba Nuclear Station 1	North Carolina Electric Membership Corp.	No		
		Saluda River Electric Cooperative, Inc.	No		
		Duke Energy Corporation	No		
19	Catawba Nuclear Station 2	North Carolina Municipal Power Agency No. 1	No		
		Piedmont Municipal Power Agency	No		
20	Clinton Power Station	AmerGen Energy Company, LLC	Yes	11/24/1999	Exelon Corporation
21	Columbia Generation Station	Energy Northwest	No		
22	Comanche Peak Steam Electric Station 1	TXU Generation Company LP	No		
23	Comanche Peak Steam Electric Station 2	TXU Generation Company LP	No		
24	Cook (Donald C.) Nuclear Power Plant 1	Indiana Michigan Power Company	No		
25	Cook (Donald C.) Nuclear Power Plant 2	Indiana Michigan Power Company	No		
26	Cooper Nuclear Station	Nebraska Public Power District	No		
27	Crystal River Nuclear Plant 3	Florida Power Corporation	No		
		City of Alachua	No		
		City of Bushnell	No		
		City of Gainesville	No		
		City of Kissimmee	No		
		City of Leesburg	No		
		City of New Smyrna Beach and Utilities Commission	No		
		City of Ocala	No		
		Orlando Utilities Commission and City of Orlando	No		
		Seminole Electric Cooperative, Inc.	No		
28	Davis-Besse Nuclear Power Station	Cleveland Electric Illumination Company	No		
		Toledo Edison Company	No		
29	Diablo Canyon Nuclear Power Plant 1	Pacific Gas and Electric Company	No		

(Continued From Previous Page)

	Plant	Licensed to own	LLC	License transfer date	LLC parent company
30	Diablo Canyon Nuclear Power Plant 2	Pacific Gas and Electric Company	No		
31	Dresden Nuclear Power Station 2	Exelon Generation Company, LLC	Yes	8/3/2000	Exelon Corporation
32	Dresden Nuclear Power Station 3	Exelon Generation Company, LLC	Yes	8/3/2000	Exelon Corporation
33	Farley (Joseph M.) Nuclear Plant 1	Alabama Power Company	No		
34	Farley (Joseph M.) Nuclear Plant 2	Alabama Power Company	No		
35	Fermi (Enrico) Atomic Power Plant 2	Detroit Edison Company	No		
36	FitzPatrick (James A.) Nuclear Power Plant	Entergy Nuclear FitzPatrick, LLC	Yes	11/21/2000	Entergy Corporation
37	Fort Calhoun Station	Omaha Public Power District	No		
38	Ginna (Robert E.) Nuclear Station	Rochester Gas and Electric Corporation	No		
39	Grand Gulf Nuclear Station	System Energy Resources, Inc.	No		
		South Mississippi Electric Power Assoc.	No		
40	Harris (Shearon) Nuclear Power Plant	Carolina Power & Light Co.	No		
		North Carolina Eastern Municipal Power Agency	No		
41	Hatch (Edwin I.) Nuclear Plant 1	Georgia Power Company	No		
		Municipal Electric Authority of Georgia	No		
		Oglethorpe Power Corporation	No		
		City of Dalton, Georgia	No		
42	Hatch (Edwin I.) Nuclear Plant 2	Georgia Power Company	No		
		Municipal Electric Authority of Georgia	No		
		Oglethorpe Power Corporation	No		
		City of Dalton, Georgia	No		
43	Hope Creek Nuclear Power Station	PSEG Nuclear, LLC	Yes	8/21/2000; 10/18/2001	Public Service Enterprise Group, Incorporated
44	Indian Point 2	Entergy Nuclear Indian Point 2, LLC	Yes	9/6/2001	Entergy Corporation
45	Indian Point 3	Entergy Nuclear Indian Point 3, LLC	Yes	11/21/2000	Entergy Corporation
46	Kewaunee Nuclear Power Plant	Wisconsin Public Service Corp.	No		
		Wisconsin Power & Light Company	No		

(Continued From Previous Page)

	Plant	Licensed to own	LLC	License transfer date	LLC parent company
47	LaSalle County Station 1	Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
48	LaSalle County Station 2	Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
49	Limerick Generating Station 1	Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
50	Limerick Generating Station 2	Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
51	McGuire (William B.) Nuclear Station 1	Duke Energy Corporation	No		
52	McGuire (William B.) Nuclear Station 2	Duke Energy Corporation	No		
53	Millstone Nuclear Power Station 2	Dominion Nuclear Connecticut, Inc.	No		
54	Millstone Nuclear Power Station 3	Dominion Nuclear Connecticut, Inc.	No		
		Central Vermont Public Service Corporation	No		
		Massachusetts Municipal Wholesale Electric Co.	No		
55	Monticello Nuclear Generating Plant	Northern States Power Company	No		
56	Nine Mile Point Nuclear Station 1	Nine Mile Point Nuclear Station, LLC	Yes	11/7/2001	Constellation Energy Group
57	Nine Mile Point Nuclear Station 2	Nine Mile Point Nuclear Station, LLC	Yes	11/7/2001	Constellation Energy Group
		Long Island Lighting Company	No		
58	North Anna Power Station 1	Virginia Electric and Power Company	No		
		Old Dominion Electric Cooperative	No		
59	North Anna Power Station 2	Virginia Electric and Power Company	No		
		Old Dominion Electric Cooperative	No		
60	Oconee Nuclear Station 1	Duke Energy Corporation	No		
61	Oconee Nuclear Station 2	Duke Energy Corporation	No		
62	Oconee Nuclear Station 3	Duke Energy Corporation	No		
63	Oyster Creek Nuclear Power Plant	AmerGen Energy Company, LLC	Yes	8/8/2000	Exelon Corporation
64	Palisades Nuclear Plant	Consumers Energy Company	No		
65	Palo Verde Nuclear Generating Station 1	Arizona Public Service Company	No		
		Salt River Project Agricultural Improvement and Power District	No		
		El Paso Electric Company	No		

(Continued From Previous Page)

	Plant	Licensed to own	LLC	License transfer date	LLC parent company
		Southern California Edison Company	No		
		Public Service Company of New Mexico	No		
		Los Angeles Dept. of Water and Power	No		
		Southern California Public Power Authority	No		
66	Palo Verde Nuclear Generating Station 2	Arizona Public Service Company	No		
		Salt River Project Agricultural Improvement and Power District	No		
		El Paso Electric Company	No		
		Southern California Edison Company	No		
		Public Service Company of New Mexico	No		
		Los Angeles Dept. of Water and Power	No		
		Southern California Public Power Authority	No		
67	Palo Verde Nuclear Generating Station 3	Arizona Public Service Company	No		
		Salt River Project Agricultural Improvement and Power District	No		
		El Paso Electric Company	No		
		Southern California Edison Company	No		
		Public Service Company of New Mexico	No		
		Los Angeles Dept. of Water and Power	No		
		Southern California Public Power Authority	No		
68	Peach Bottom Atomic Power Station 2	Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
		PSEG Nuclear, LLC	Yes		Public Service Enterprise Group, Incorporated
69	Peach Bottom Atomic Power Station 3	Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
		PSEG Nuclear, LLC	Yes		Public Service Enterprise Group, Incorporated
70	Perry Nuclear Power Plant	Ohio Edison Company	No		
		Cleveland Electric Company	No		
		Toledo Edison Company	No		
71	Pilgrim Station	Entergy Nuclear Generation Co.	No		
72	Point Beach Nuclear Plant 1	Wisconsin Electric Power Company	No		
73	Point Beach Nuclear Plant 2	Wisconsin Electric Power Company	No		

(Continued From Previous Page)

	Plant	Licensed to own	LLC	License transfer date	LLC parent company
74	Praire Island Nuclear Plant 1	Northern States Power Company	No		
75	Praire Island Nuclear Plant 2	Northern States Power Company	No		
76	Quad Cities Station 1	Exelon Generation Company, LLC	Yes	8/3/2000	Exelon Corporation
		MidAmerican Energy Company	No		
77	Quad Cities Station 2	Exelon Generation Company, LLC	Yes	8/3/2000	Exelon Corporation
		MidAmerican Energy Company	No		
78	River Bend Station	Entergy Gulf States, Inc.	No		
79	Robinson (H. B.) Plant 2	Carolina Power & Light Co.	No		
80	Salem Nuclear Generating Station 1	PSEG Nuclear, LLC	Yes	8/21/2000	Public Service Enterprise Group, Incorporated
		Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
81	Salem Nuclear Generating Station 2	PSEG Nuclear, LLC	Yes	8/21/2000	Public Service Enterprise Group, Incorporated
		Exelon Generation Company, LLC	Yes	1/12/2001	Exelon Corporation
82	San Onofre Nuclear Generating Station 2	Southern California Edison Company	No		
83	San Onofre Nuclear Generating Station 3	Southern California Edison Company	No		
84	Seabrook Nuclear Power Station	FPL Energy Seabrook, LLC	Yes	11/1/2002	FPL Group, Inc.
		Massachusetts Municipal Wholesale Electric Co.	No		
		Tauton Municipal Lighting Plant	No		
		Hudson Light & Power Department	No		
85	Sequoya Nuclear Plant 1	Tennessee Valley Authority	No		
86	Sequoya Nuclear Plant 2	Tennessee Valley Authority	No		
87	South Texas Project 1	Texas Genco, LP	No		
		City Public Service Board of San Antonio	No		
		Central Power & Light Company	No		
		City of Austin, Texas	No		
88	South Texas Project 2	Texas Genco, LP	No		
		City Public Service Board of San Antonio	No		
		Central Power & Light Company	No		
		City of Austin, Texas	No		
89	St. Lucie Plant 1	Florida Power and Light Company	No		

(Continued From Previous Page)

	Plant	Licensed to own	LLC	License transfer date	LLC parent company
90	St. Lucie Plant 2	Florida Power and Light Company	No		
		Florida Municipal Power Agency	No		
		Orlando Utilities Commission	No		
91	Summer (Virgil C.) Nuclear Station	South Carolina Electric & Gas Company	No		
		South Carolina Public Service Authority	No		
92	Surry Power Station 1	Virginia Electric and Power Company	No		
93	Surry Power Station 2	Virginia Electric and Power Company	No		
94	Susquehanna Steam Electric Station 1	PPL Susquehanna, LLC	Yes	6/1/2000	Pennsylvania Power and Light Company
95	Susquehanna Steam Electric Station 2	PPL Susquehanna, LLC	Yes	6/1/2000	Pennsylvania Power and Light Company
96	Three Mile Island Nuclear Station 1	AmerGen Energy Company, LLC	Yes	12/20/1999	Exelon Corporation
97	Turkey Point Station 3	Florida Power and Light Company	No		
98	Turkey Point Station 4	Florida Power and Light Company	No		
99	Vermont Yankee Nuclear Power Station	Entergy Nuclear Vermont Yankee, LLC	Yes	7/1/2002	Entergy Corporation
		Entergy Nuclear Operations, Inc.	No		
100	Vogtle (Alvin W.) Nuclear Plant 1	Georgia Power Company	No		
		Municipal Electric Authority of Georgia	No		
		Oglethorpe Power Corporation	No		
		City of Dalton, Georgia	No		
101	Vogtle (Alvin W.) Nuclear Plant 2	Georgia Power Company	No		
		Municipal Electric Authority of Georgia	No		
		Oglethorpe Power Corporation	No		
		City of Dalton, Georgia	No		
102	Waterford Generating Station 3	Entergy Operations, Inc.	No		
103	Watts Bar Nuclear Plant 1	Tennessee Valley Authority	No		
104	Wolf Creek Generating Station	Kansas Gas & Electric Company	No		
		Kansas City Power & Light Company	No		
		Kansas Electric Power Cooperative, Inc.	No		

Source: GAO survey of NRC Project Managers.

Appendix II

Comments from the Nuclear Regulatory Commission

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 29, 2004

Mr. James E. Wells
Director, Natural Resources and Environment
United States General Accounting Office
441 G Street, N.W.
Washington, DC 20548

Dear Mr. Wells:

I would like to thank you for the opportunity to review and submit comments on the May 2004 draft of the General Accounting Office's (GAO) report entitled "Nuclear Regulation-NRC's Liability Insurance Requirements for Nuclear Power Plants Owned by Limited Liability Companies." The U.S. Nuclear Regulatory Commission (NRC) appreciates the time and effort that you and your staff have taken to review this topic.

GAO correctly concludes that NRC does not treat limited liability companies differently than other licensees with respect to the Price-Anderson's insurance requirements. Like other licensees, limited liability companies must show proof of both primary and secondary financial protection. GAO also is correct in noting that NRC is not aware of any problems caused by limited liability companies owning nuclear power plants and that NRC currently does not regard limited liability companies' ownership of nuclear power plants as a concern. Finally, GAO agrees with NRC's conclusion that all its reactor licensees have sufficient assets that they are likely to be able to pay the retrospective premiums. These assets are assured by a number of different methods that are approved by NRC as GAO discusses in its report.

The NRC believes that the GAO report accurately reflects the present insurance system for nuclear power plants. Therefore, we do not have any comments to provide regarding the draft report.

Sincerely,

William D. Travers
Executive Director
for Operations

cc: Ilene Pollack, GAO

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United States General Accounting Office

GAO

Report to Congressional Requesters

May 2004

NUCLEAR REGULATION

NRC Needs to More Aggressively and Comprehensively Resolve Issues Related to the Davis-Besse Nuclear Power Plant's Shutdown

GAO

Accountability * Integrity * Reliability

GAO-04-415

May 2004

GAO
Accountability·Integrity·Reliability

Highlights

Highlights of GAO-04-415, a report to congressional requesters

NUCLEAR REGULATION

NRC Needs to More Aggressively and Comprehensively Resolve Issues Related to the Davis-Besse Nuclear Power Plant's Shutdown

Why GAO Did This Study

In March 2002, the most serious safety issue confronting the nation's commercial nuclear power industry since Three Mile Island in 1979 was identified at the Davis-Besse plant in Ohio. After the Nuclear Regulatory Commission (NRC) allowed Davis-Besse to delay shutting down to inspect its reactor vessel for cracked tubing, the plant found that leakage from these tubes had caused extensive corrosion on the vessel head—a vital barrier preventing a radioactive release. GAO determined (1) why NRC did not identify and prevent the corrosion, (2) whether the process NRC used in deciding to delay the shutdown was credible, and (3) whether NRC is taking sufficient action in the wake of the incident to prevent similar problems from developing at other plants.

What GAO Recommends

Because the nation's nuclear power plants are aging, GAO is recommending that NRC take more aggressive actions to mitigate the risk of serious safety problems occurring at Davis-Besse and other nuclear power plants.

NRC disagreed with two of the report's five recommendations—that it develop (1) additional means to better identify safety problems early and (2) guidance for making decisions whether to shut down a plant. GAO continues to believe these recommendations are appropriate and should be implemented.

www.gao.gov/cgi-bin/getrpt?GAO-04-415.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells at (202) 512-3841 or wellsj@gao.gov.

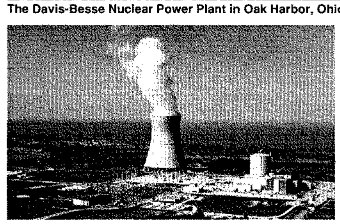
What GAO Found

NRC should have but did not identify or prevent the corrosion at Davis-Besse because its oversight did not generate accurate information on plant conditions. NRC inspectors were aware of indications of leaking tubes and corrosion; however, the inspectors did not recognize the indications' importance and did not fully communicate information about them. NRC also considered FirstEnergy—Davis-Besse's owner—a good performer, which resulted in fewer NRC inspections and questions about plant conditions. NRC was aware of the potential for cracked tubes and corrosion at plants like Davis-Besse but did not view them as an immediate concern. Thus, NRC did not modify its inspections to identify these conditions.

NRC's process for deciding to allow Davis-Besse to delay its shutdown lacks credibility. Because NRC had no guidance specifically for making a decision on whether a plant should shut down, it used guidance for deciding whether a plant should be allowed to modify its operating license. NRC did not always follow this guidance and generally did not document how it applied the guidance. The risk estimate NRC used to help decide whether the plant should shut down was also flawed and underestimated the amount of risk that Davis-Besse posed. Further, even though underestimated, the estimate still exceeded risk levels generally accepted by the agency.

NRC has taken several significant actions to help prevent reactor vessel corrosion from recurring at nuclear power plants. For example, NRC has required more extensive vessel examinations and augmented inspector training. However, NRC has not yet completed all of its planned actions and, more importantly, has no plans to address three systemic weaknesses underscored by the incident. Specifically, NRC has proposed no actions to help it better (1) identify early indications of deteriorating safety conditions at plants, (2) decide whether to shut down a plant, or (3) monitor actions taken in response to incidents at plants. Both NRC and GAO had previously identified problems in NRC programs that contributed to the Davis-Besse incident, yet these problems continue to persist.

The Davis-Besse Nuclear Power Plant in Oak Harbor, Ohio



Source: FirstEnergy.

Contents

Abbreviations

NRC	Nuclear Regulatory Commission
PRA	Probabilistic risk assessment

GAO
Accountability * Integrity * Reliability
United States General Accounting Office
Washington, D.C. 20548

May 17, 2004

Congressional Requesters

In 2002, the most serious safety issue confronting the nation's commercial nuclear power industry since the accident at Three Mile Island in 1979 was identified at the Davis-Besse nuclear power plant in northwestern Ohio. On March 7, 2002, during shutdown for inspection and refueling, the owner of the Davis-Besse plant—FirstEnergy Nuclear Operating Company—discovered a pineapple-sized cavity in the plant's carbon steel reactor vessel head. The reactor vessel head is an 18-foot-diameter, 6-inch-thick, 80-ton cap that is bolted to the reactor vessel. The vessel head is an integral part of the reactor coolant pressure boundary that serves as a vital barrier for protecting the environment from any release of radiation from the reactor core. In pressurized water reactors such as the one at Davis-Besse, the reactor vessel contains the nuclear fuel, as well as water with diluted boric acid that cools the fuel and helps control the nuclear reaction. At the Davis-Besse plant, vertical tubes had cracked that penetrate the reactor vessel head and that contain this water as well as drive mechanisms used to lower and raise the fuel, thus allowing leaked boric acid to corrode the reactor vessel head. The corrosion had extended through the vessel head to a thin stainless steel lining and had likely occurred over a period of several years. The lining, which is less than one-third of an inch thick and was not designed as a pressure barrier, was found to have a slight bulge with evidence of cracking. Had this lining given way, the water within the reactor vessel would have escaped, triggering a loss-of-coolant accident, which—if back-up safety systems had failed to operate—likely would have resulted in the melting of the radioactive core and a subsequent release of radioactive materials into the environment. In March 2004, after 2 years of increased NRC oversight and considerable repairs by FirstEnergy, NRC approved the restart of Davis-Besse's operations.

Under the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended, the Nuclear Regulatory Commission (NRC) and the operators of nuclear power plants share the responsibility for ensuring that nuclear reactors are operated safely. NRC is responsible for issuing regulations, licensing and inspecting plants, and requiring action, as necessary, to protect public health and safety; plant operators have the primary responsibility for safely operating the plants in accordance with their licenses. NRC has the authority to order plant operators to take actions, up to and including shutting down a plant, if licensing conditions are not being met and the plant poses an undue risk to

public health and safety. In carrying out its responsibilities, NRC relies on, among other things, on-site NRC resident inspectors to assess plant conditions and quality assurance programs, such as those for maintenance and operations, that operators establish to ensure safety at the plant.

Before the discovery of the cavity in the Davis-Besse reactor vessel head, NRC had requested that operators of Davis-Besse and other similar pressurized water reactors (1) thoroughly inspect the vertical tubing on their reactor vessel heads by December 31, 2001, for possible cracking, or (2) justify why their tubing and reactor vessel heads were sufficiently safe without being inspected. This request was a reaction to cracked vertical tubing found on a pressurized water reactor vessel head at another plant. Such thorough inspections require that the reactor be shut down. FirstEnergy, believing that its reactor vessel head was safe, asked NRC if its shutdown could be delayed until the end of March 2002 to coincide with an already scheduled shutdown for refueling—during which time it would conduct the requested inspection. FirstEnergy provided evidence supporting its assertion that the reactor could continue operating safely. After considerable discussion, and after NRC developed a risk assessment estimate for deciding that Davis-Besse would not pose an unacceptable level of risk, NRC and FirstEnergy compromised, and FirstEnergy agreed to shut down the reactor in mid-February 2002 for inspection. Soon after Davis-Besse was shut down, the cracked tubes and the significant reactor vessel head corrosion were discovered.

You asked us to determine (1) why NRC did not identify and prevent the vessel head corrosion at Davis-Besse, (2) whether the process NRC used when deciding to allow FirstEnergy to delay its shutdown was credible, and (3) whether NRC is taking sufficient action in the wake of the Davis-Besse incident to prevent similar problems from developing in the future at Davis-Besse and other nuclear power plants. As agreed with your offices, our review focused on NRC's role in the events leading up to Davis-Besse's shutdown, NRC's response to the problems discovered, and NRC's management controls over programs and processes that may have contributed to the Davis-Besse incident. We did not evaluate the role of FirstEnergy because, at the time of our review, NRC's Office of Investigations and the Department of Justice were conducting separate inquiries into the potential liability of FirstEnergy concerning its knowledge of conditions at Davis-Besse, including the condition of the reactor vessel head. We also did not review NRC's March 2004 decision to allow the plant to restart.

Scope and Methodology

To determine why NRC did not identify and prevent the vessel head corrosion at the Davis-Besse nuclear power plant, we reviewed NRC's lessons-learned task force report;[1] FirstEnergy's root cause analysis reports;[2] NRC's Office of the Inspector General reports on Davis-Besse;[3] NRC's augmented inspection team report;[4] and NRC's inspection reports and licensee assessments from 1998 through 2001. We also reviewed NRC generic communications issued on boric acid corrosion and on nozzle cracking. In addition, we interviewed NRC regional officials who were involved in overseeing Davis-Besse at the time corrosion was occurring, and when the reactor vessel head cavity was found, to learn what information they had, their knowledge of plant activities, and how they communicated information to headquarters. We also held discussions with the resident inspector who was at Davis-Besse at the time that corrosion was occurring to determine what information he had and how this information was communicated to the regional office. Further, we met with FirstEnergy and NRC officials at Davis-Besse and walked through the facility, including the containment building, to understand the nature and extent of NRC's oversight of licensees. Additionally, we met with NRC headquarters officials to discuss the oversight process as it related to Davis-Besse, and the extent of their knowledge of conditions at Davis-Besse. We also met with county officials from Ottawa County, Ohio, to discuss their views on NRC and Davis-Besse plant safety. Further, we met with representatives from a variety of public interest groups to obtain their thoughts on NRC's oversight and the agency's proposed changes in the wake of Davis-Besse.

[1]NRC, *Degradation of Davis-Besse Nuclear Power Station Reactor Pressure Vessel Head Lessons-Learned Report* (Washington, D.C.; Sept. 30, 2002).

[2]FirstEnergy, Davis-Besse Nuclear Power Station, *Root Cause Analysis Report: Significant Degradation of the Reactor Pressure Vessel Head, CR 2002-089* (Oak Harbor, Ohio; Aug. 27, 2002) and *Root Cause Analysis Report: Failure to Identify Significant Degradation of the Reactor Pressure Vessel Head, CR-02-0685, 02-0846, 02-0891, 02-1053, 02-1128, 02-1583, 02-1850, 02-2584, and 02-2585* (Oak Harbor, Ohio; Aug. 13, 2002).

[3]NRC, Office of the Inspector General, *NRC's Regulation of Davis-Besse Regarding Damage to the Reactor Vessel Head* (Washington, D.C.; Dec. 30, 2002) and *NRC's Oversight of Davis-Besse Boric Acid Leakage and Corrosion during the April 2000 Refueling Outage* (Washington, D.C.: Oct. 17, 2003).

[4]NRC, *Davis-Besse Nuclear Power Station NRC Augmented Inspection Team—Degradation of the Reactor Pressure Vessel Head* (Washington, D.C.; May 3, 2002).

To determine whether the process NRC used was credible when deciding to allow Davis-Besse to delay its shutdown, we evaluated NRC guidelines for reviewing licensee requests for temporary and permanent license changes, or amendments to their licenses. We also reviewed NRC guidance for making and documenting agency decisions, such as those on whether to accept licensee responses to generic communications, as well as NRC's policies and procedures for taking enforcement action. We supplemented these reviews with an analysis of internal NRC correspondence related to the decision-making process, including e-mail correspondence, notes, and briefing slides. We also reviewed NRC's request for additional information to FirstEnergy following the issuance of NRC's generic bulletin for conducting reactor vessel head and nozzle inspections, as well as responses provided by FirstEnergy. In addition, we reviewed the draft shutdown order that NRC prepared before accepting FirstEnergy's proposal to conduct its inspection in mid-February 2002. We reviewed these documents to determine whether the basis for NRC's decision was clearly laid out, persuasive, and defensible to a party outside of NRC.

As part of our analysis for determining whether NRC's process was credible, we also obtained and reviewed NRC's probabilistic risk assessment (PRA) calculations that it developed to guide its decision making. To conduct this analysis, we relied on the advice of consultants who, collectively, have an extensive background in nuclear engineering, PRA, and metallurgy. These consultants included Dr. John C. Lee, Professor and Chair, Nuclear Engineering and Radiological Sciences at the University of Michigan's College of Engineering; Dr. Thomas H. Pigford, Professor Emeritus, at the University of California-Berkeley's College of Engineering; and Dr. Gary S. Was, Associate Dean for Research in the College of Engineering, and Professor, Nuclear Engineering and Radiological Sciences at the University of Michigan's College of Engineering. These consultants reviewed internal NRC correspondence relating to NRC's PRA estimate, NRC's calculations, and the basis for these calculations. These consultants also discussed the basis for NRC's estimates with NRC officials and outside contractors who provided information to NRC as it developed its estimates. These consultants were selected on the basis of recommendations made by other nuclear engineering experts, their résumés, their collective experience, lack of a conflict of interest, and previous experience with assessing incidents at nuclear power plants such as Three Mile Island.

To determine whether NRC is taking sufficient action in the wake of the Davis-Besse incident to prevent similar problems from developing in the future, we reviewed NRC's lessons-learned task force recommendations,

NRC's analysis of the underlying causes for failing to identify the corrosion of the reactor vessel head, and NRC's action plan developed in response to the task force recommendations. We also reviewed other NRC lessons-learned task force reports and their recommendations, our prior reports to identify issues related to those at Davis-Besse, and NRC's Office of the Inspector General reports. We met with NRC officials responsible for implementing task force recommendations to obtain a clear understanding of the actions they were taking and the status of their efforts, and discussed NRC's recommendations with NRC regional officials, on-site inspectors, and representatives from public interest groups. We conducted our review from November 2002 through May 2004 in accordance with generally accepted government auditing standards.

Results in Brief

NRC should have but did not identify or prevent the vessel head corrosion at Davis-Besse because both its inspections at the plant and its assessments of the operator's performance yielded inaccurate and incomplete information on plant safety conditions. With respect to inspections, NRC resident inspectors had information revealing potential problems, such as boric acid deposits on the vessel head and air monitors clogged with boric acid deposits, but this information did not raise alarms about the plant's safety. NRC inspectors did not know that these indications could signal a potentially significant problem and therefore did not fully communicate their observations to other NRC staff, some of whom might have recognized the significance of the problem. However, even if these staff had been informed, according to NRC officials, the agency would have taken action only if these indications were considered significant safety concerns. Furthermore, NRC's assessments of Davis-Besse, which include inspection results as well as other data, did not provide complete and accurate information on FirstEnergy's performance. For example, NRC consistently assessed Davis-Besse's operator as a "good performer" during those years when the corrosion was likely occurring, and the operator was not correctly identifying the source of boric acid deposits. NRC had been aware for several years that corrosion and cracking were issues that could possibly affect safety, but did not view them as immediate safety concerns and therefore had not fully incorporated them into its oversight process.

NRC's process for deciding whether Davis-Besse could delay its shutdown to inspect for nozzle cracking lacks credibility because the guidance NRC used was not intended for making such a decision and the basis for the decision was not fully documented. In the absence of written guidance specifically intended to direct the decision-making process for a shutdown,

NRC used guidance designed for considering operator requests for license amendments. This guidance describes safety factors that NRC should consider in deciding whether to approve a license amendment, as well as a process for considering the relative risk the amendment could pose. However, the guidance does not specify how NRC should use the safety factors, and we could not determine if NRC appropriately followed this guidance because it did not clearly document the basis for its decision. For example, NRC initially decided that several safety factors were not met and considered issuing a shutdown order. Regardless, the agency allowed FirstEnergy to delay its shutdown, even though it is not clear whether—and if so, how—the safety factors were subsequently met. Further, NRC did not provide a rationale for its decision for more than a year. NRC also did not follow other aspects of its guidance. In the absence of specific guidance, and with little documentation of the decision-making process, we could not judge whether the agency's decision was reasonable. Our consultants identified substantial problems with how NRC developed and used its risk estimate when making the decision. For example, NRC did not perform an analysis of the uncertainty associated with the risk estimate; if it had, our consultants believe the uncertainty would have been so large as to render NRC's risk estimate of questionable value. Further, the risk estimate indicated that the likelihood of an accident occurring at Davis-Besse was greater than the level of risk generally accepted as being reasonable by NRC.

Responding to the Davis-Besse incident, NRC has taken several significant actions to help prevent boric acid from corroding reactor vessel heads at nuclear power plants. NRC issued requirements that licensees more extensively examine their reactor vessel heads, revised NRC inspection guidance used to identify and resolve licensee problems before they affect operations, augmented training to keep its inspectors better informed about boric acid and cracking issues, and revised guidance to better ensure that licensees implement commitments to change their operations. However, NRC has not yet implemented more than half of its planned actions, and resource constraints could affect the agency's ability to fully and effectively implement the actions. More importantly, NRC is not addressing three systemic problems underscored by the Davis-Besse incident. First, its process for assessing safety at nuclear power plants is not adequate for detecting early indications of deteriorating safety. In this respect, the process does not effectively identify changes in the operator's performance or approach to safety before a more serious safety problem can develop. Second, NRC's decision-making guidance does not specifically address shutdown decisions or explain how different safety

considerations, such as quantitative estimates of risk, should be weighed. Third, NRC does not have adequate management controls for systematically tracking actions that it has taken in response to incidents at plants to determine if the actions were sufficient to resolve underlying problems and thereby prevent future incidents. Analyses of earlier incidents at other plants identified several issues, such as inadequate communication, that contributed to the Davis-Besse incident. Such management controls may have helped to resolve these issues before the Davis-Besse incident occurred. While NRC is monitoring how it implements actions taken as a result of the Davis-Besse incident, the agency has not yet committed to a process for assessing the effectiveness of actions taken.

Given NRC's actions in response to Davis-Besse, severe vessel head corrosion is unlikely to occur at a plant any time soon. However, in part because of unresolved systemic problems, another incident unrelated to vessel head corrosion could occur in the future. As a result, we are recommending that NRC take more aggressive and specific actions in several areas, such as revising how it assesses plant performance, establishing a more specific methodology for deciding to shut down a plant, and establishing management controls for monitoring and assessing the effectiveness of changes made in response to task force findings.

In commenting on a draft of this report, NRC generally addressed only those findings and recommendations with which it disagreed. While commenting that it agreed with many of our findings, the agency said that the report overall does not appropriately characterize or provide a balanced perspective on NRC's actions surrounding the discovery of the reactor vessel head condition at Davis-Besse or its efforts to incorporate the lessons learned from that experience into its processes. More specifically, NRC stated that the report does not acknowledge that NRC must rely heavily on its licensees to provide complete and accurate information. NRC also expressed concern about the report's characterization of its use of risk estimates. We believe that the report fairly and accurately describes NRC's actions regarding the Davis-Besse incident. Nonetheless, we expanded our discussion of NRC's roles and responsibilities to point out that licensees are required to provide NRC with complete and accurate information.

NRC disagreed with our recommendations to develop (1) specific guidance and a well-defined process for deciding when to shut down a plant and (2) a methodology to assess early indications of deteriorating safety at nuclear

power plants. NRC stated that it has sufficient guidance to make plant shutdown decisions. NRC also stated that, as regulators, the agency is not charged with managing licensees' facilities and that direct involvement with those aspects of licensees' operations that could provide it with information on early indications of deteriorating safety crosses over to a management function. We continue to believe that NRC should develop specific guidance and a well-defined process to decide when to shut down a plant. In absence of such guidance for making the Davis-Besse shutdown decision, NRC used its guidance for considering operators' requests for amendments to their licenses. This guidance describes safety factors that NRC should consider in deciding whether to approve license changes, as well as a process for considering the relative risk the amendment would pose. This guidance does not specify how NRC should use the safety factors. We also continue to believe that NRC should develop a methodology to assess aspects of licensees' operations as a means to have an early warning of developing safety problems. In implementing this recommendation, we envision that NRC would be analyzing data for changes in operators' performance or approach to safety, not prescribing how the plants are managed.

Background

NRC's Role and Responsibilities

NRC, as an independent federal agency, regulates the commercial uses of nuclear material to ensure adequate protection of public health and safety and the environment. NRC is headed by a five-member commission appointed by the President and confirmed by the Senate; one commissioner is appointed as chairman.[5] NRC has about 2,900 employees who work in its headquarters office in Rockville, Maryland, and its four regional offices. NRC is financed primarily by fees that it imposes on commercial users of the nuclear material that it regulates. For fiscal year 2004, NRC's appropriated budget of $626 million includes about $546 million financed by these fees.

NRC regulates the nation's commercial nuclear power plants by establishing requirements for plant owners and operators to follow in the design, construction, and operation of the nuclear reactors. NRC also

[5] Two commissioner positions are currently vacant.

licenses the reactors and individuals who operate them. Currently, 104 commercial nuclear reactors at 65 locations are licensed to operate.[6] Many of these reactors have been in service since the early to mid-1970s. NRC initially licensed the reactors to operate for 40 years, but as these licenses approach their expiration dates, NRC has been granting 20-year extensions.

To ensure the reactors are operated within their licensing requirements and technical specifications, NRC oversees them by both inspecting activities at the plants and assessing plant performance.[7] NRC's inspections consist of both routine, or baseline, inspections and supplemental inspections to assess particular licensee programs or issues that arise at a power plant. Inspections may also occur in response to a specific operational problem or event that has occurred at a plant. NRC maintains inspectors at every operating nuclear power plant in the United States and supplements the inspections conducted by these resident inspectors with inspections conducted by staff from its regional offices and from headquarters. Generally, inspectors verify that the plant's operator qualifications and operations, engineering, maintenance, fuel handling, emergency preparedness, and environmental and radiation protection programs are adequate and comply with NRC safety requirements. NRC also oversees licensees by requesting information on their activities. NRC requires that information provided by licensees be complete and accurate and, according to NRC officials, this is an important aspect of the agency's oversight.[8] While we have added information to this report on the requirement that licensees provide NRC with complete and accurate information, we believe that NRC's oversight program should not place undue reliance on this requirement.

Nuclear power plants have many physical structures, systems, and components, and licensees have numerous activities under way, 24-hours a

[6]These licensed reactors include Browns Ferry Unit 1—one of three reactors owned by the Tennessee Valley Authority in Alabama—which was shut down in 1985. The Tennessee Valley Authority plans to restart the reactor in 2007, which will require NRC approval.

[7]NRC's oversight program has changed significantly since the beginning of 1998. The third and most recent change occurred in mid-2000, when the agency adopted its Reactor Oversight Process. Under this process, NRC continues to rely on inspection results to assess licensee performance. However, it supplements this information with other indicators of self-reported licensee performance, such as how frequently unscheduled shutdowns occur.

[8]10 C.F.R. § 50.9 requires that information provided by licensees be complete and accurate in all material respects.

day, to ensure the plants operate safely. Programs to ensure quality assurance and safe operations include monitoring, maintenance, and inspection. To carry out these programs, licensees typically prepare several thousand reports per year describing conditions at the plant that need to be addressed to ensure continued safe operations. Because of the large number of activities and physical structures, systems, and components, NRC focuses its inspections on those activities and pieces of equipment or systems that are considered to be most significant for protecting public health and safety. NRC terms this a "risk-informed" approach for regulating nuclear power plants. Under this risk-informed approach, some systems and activities that NRC considers to have relatively less safety significance receive little NRC oversight. NRC has adopted a risk-informed approach because it believes it can focus its regulatory resources on those areas of the plant that the agency considers to be most important to safety. In addition, it was able to adopt this approach because, according to NRC, safety performance at nuclear power plants has improved as a result of more than 25 years of operating experience.

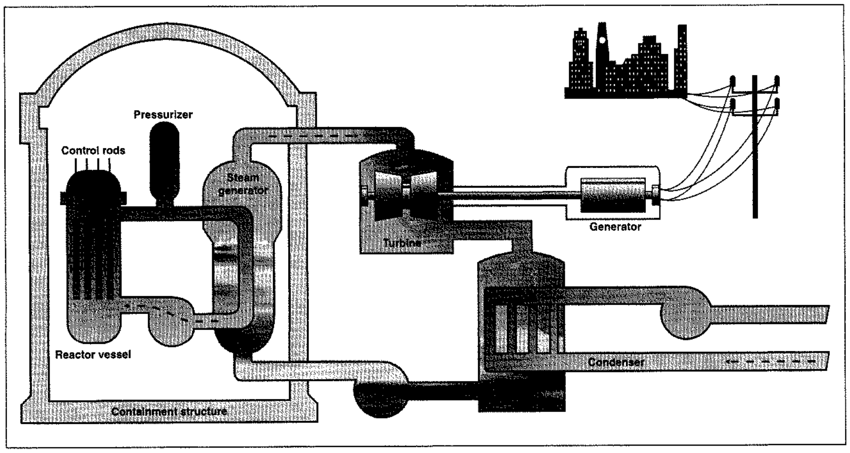
To decide whether inspection findings are minor or major, NRC uses a process it began in 2000 to determine the extent to which violations compromise plant safety. Under this process, NRC characterizes the significance of its inspection findings by using a significance determination process to evaluate how an inspection finding impacts the margin of safety at a power plant. NRC has a range of enforcement actions it can take, depending on how much the safety of the plant had been compromised. For findings that have low safety significance, NRC can choose to take no formal enforcement action. In these instances, nonetheless, licensees remain responsible for addressing the identified problems. For more serious findings, NRC may take more formal action, such as issuing enforcement orders. Orders can be used to modify, suspend, or even revoke an operating license. NRC has issued one enforcement order to shut down an operating power plant in its 28-year history—in 1987, after NRC discovered control room personnel sleeping while on duty at the Peach Bottom nuclear power plant in Pennsylvania. In addition to enforcement orders, NRC can issue civil penalties of up to $120,000 per violation per day. Although NRC does not normally use civil penalties for violations associated with its Reactor Oversight Process, NRC will consider using them for issues that are willful, have the potential for impacting the agency's regulatory process, or have actual public health and safety consequences. In fiscal year 2003, NRC proposed imposing civil penalties totaling $120,000 against two power plant licensees for the failure to provide complete and accurate information to the agency.

NRC uses generic communications—such as bulletins, generic letters, and information notices—to provide information to and request information from the nuclear industry at large or specific groups of licensees. Bulletins and generic letters both usually request information from licensees regarding their compliance with specific regulations. They do not require licensees to take any specific actions, but do require licensees to provide responses to the information requests. In general, NRC uses bulletins, as opposed to generic letters, to address significant issues of greater urgency. NRC uses information notices to transmit significant recently identified information about safety, safeguards, or environmental issues. Licensees are expected to review the information to determine whether it is applicable to their operations and consider action to avoid similar problems.

Operation of Pressurized Water Nuclear Power Plants and Events Leading to the March 2002 Discovery of Serious Corrosion

The Davis-Besse Nuclear Power Station, owned and operated by FirstEnergy Nuclear Operating Company, is an 882-megawatt electric pressurized water reactor located on Lake Erie in Oak Harbor, Ohio, about 20 miles east of Toledo. The power plant is under NRC's Region III oversight, which is located in Lisle, Illinois. Like other pressurized water reactors, Davis-Besse is designed with multiple barriers between the radioactive heat-producing core and the outside environment—a design concept called "defense-in-depth." Three main design components provide defense-in-depth. First, the reactor core is designed to retain radioactive material within the uranium oxide fuel, which is also covered with a layer of metal tubing. Second, a 6-inch-thick carbon steel vessel, lined with three-sixteenth-inch-thick stainless steel, surrounds the reactor core. Third, a steel containment structure, surrounded by a thick reinforced concrete building, encloses the reactor vessel and other systems and components important for maintaining safety. The containment structure and concrete building are intended to help not only prevent a release of radioactivity to the environment, but also shield the reactor from external hazards like tornados and missiles. The reactor vessel, in addition to housing the reactor core, contains highly pressurized water to cool the radioactive heat-producing core and transfer heat to a steam generator. Consequently, the vessel is referred to as the reactor pressure vessel. From the vessel, hot pressurized water is piped to the steam generator, where a separate supply of water is turned to steam to drive turbines that generate electricity. (See fig. 1.)

Figure 1: Major Components of a Pressurized Water Reactor



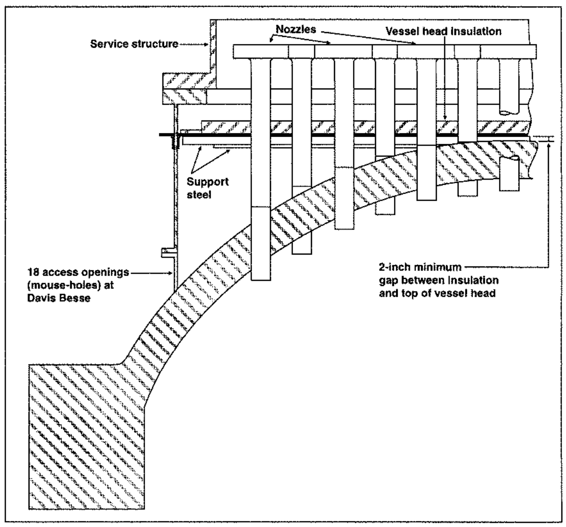
Source: NRC.

The top portion of the Davis-Besse reactor pressure vessel consisted of an 18-foot-diameter vessel head that was bolted to the lower portion of the pressure vessel. At Davis-Besse, 69 vertical tubes penetrated and were welded to the vessel head. These tubes, called vessel head penetration nozzles, contained control rods that, when raised or lowered, were used to moderate or shut down the nuclear reaction in the reactor.[9] Because control rods attach to control rod drive mechanisms, these types of nozzles are referred to as control rod drive mechanism nozzles. A platform, known as the service structure, sat above the reactor vessel head and the control rod drive mechanism nozzles. Inside the service structure and above the pressure vessel head was a layer of insulation to help contain the heat emanating from the reactor. The sides of the lower portion of the service

[9]While Davis-Besse had 69 nozzles, 7 were spare and 1 was used for head vent piping.

structure were perforated with 18 5- by 7-inch rectangular openings, termed “mouse-holes,” that were used for vessel head inspections. In pressurized water reactors such as Davis-Besse, the reactor vessel, the vessel head, the nozzles, and other equipment used to ensure a continuous supply of pressurized water in the reactor vessel are collectively referred to as the reactor coolant pressure boundary. (See fig. 2.)

Figure 2: Major Components of the Davis-Besse Reactor Vessel Head and Pressure Boundary



Source: FirstEnergy.

To better control the nuclear reaction at nuclear power plants, boron in the form of boric acid crystals is dissolved in the cooling water contained within the reactor vessel and pressure boundary. Boric acid, under certain

conditions, can cause corrosion of carbon steel. For about 3 decades, NRC and the nuclear power industry have known that boric acid had the potential to corrode reactor components. In general, if leakage occurs from the reactor coolant system, the escaping coolant will flash to steam and leave behind a concentration of impurities, including noncorrosive dry boric acid crystals. However, under certain conditions, the coolant will not flash to steam, and the boric acid will remain in a liquid state where it can cause extensive and rapid degradation of any carbon steel components it contacts. Such extensive degradation, in both domestic and foreign pressurized water reactor plants, has been well documented and led NRC to issue a generic letter in 1988 requesting information from pressurized water reactor licensees to ensure they had implemented programs to control boric acid corrosion. NRC was primarily concerned that boric acid corrosion could compromise the reactor coolant pressure boundary. This concern also led NRC to develop a procedure for inspecting licensees' boric acid corrosion control programs and led the Electric Power Research Institute to issue guidance on boric acid corrosion control.[10]

NRC and the nuclear power industry have also known that nozzles made of alloy 600,[11] used in several areas within nuclear power plants, were prone to cracking. Cracking had become an increasingly topical issue as the nuclear power plant fleet has aged. In 1986, operators at domestic and foreign pressurized water reactors began reporting leaks in various types of alloy 600 nozzles. In 1989, after leakage was detected at a domestic plant, NRC identified the cause of the leakage as cracking due to primary water stress corrosion.[12] However, NRC concluded that the cracking was not an immediate safety concern for a few reasons. For example, the cracks had a low growth rate, were in a material with an extremely high flaw tolerance and, accordingly, were unlikely to spread. Also, the cracks were axial—that is, they ran the length of the nozzle rather than its circumference. NRC and

[10]The Electric Power Research Institute is a nonprofit energy research consortium whose members include utilities. It provides science and technology-based solutions to members through its scientific research, technology development, and product implementation program.

[11]Alloy 600 is an alloy of nickel, chromium, iron, and minor amounts of other elements. The alloy is highly resistant to general corrosion but can be susceptible to cracking at high temperatures.

[12]Primary water stress corrosion cracking refers to cracking under stress and in primary coolant water. The primary water coolant system is that portion of a nuclear power plant's coolant system that cools the reactor core in the reactor pressure vessel and deposits heat to the steam generator.

the nuclear power industry were more concerned that circumferential cracks could result in broken or snapped nozzles. NRC did, however, issue a generic information notice in 1990 to inform the industry of alloy 600 cracking. Through the early 1990s, NRC, the Nuclear Energy Institute,[13] and others continued to monitor alloy 600 cracking. In 1997, continued concern over cracking led NRC to issue a generic letter to pressurized water reactor licensees requesting information on their plans to monitor and manage cracking in vessel head penetration nozzles as well as to examine these nozzles.

In the spring of 2001, licensee inspections led to the discovery of large circumferential cracking in several vessel head penetration nozzles at the Oconee Nuclear Station, in South Carolina. As a result of the discovery, the nuclear power industry and NRC categorized the 69 operating pressurized water reactors in the United States into different groups on the basis of (1) whether cracking had already been found and (2) how similar they were to Oconee in terms of the amount of time and the temperature at which the reactors had operated. The industry had developed information indicating that greater operating time and temperature were related to cracking. In total, five reactors at three locations were categorized as having already identified cracking, while seven reactors at five locations were categorized as being highly susceptible, given their similarity to Oconee.[14]

In August 2001, NRC issued a bulletin requesting that licensees of these reactors provide, within 30 days, information on their plans for conducting nozzle inspections before December 31, 2001.[15] In lieu of this information, NRC stated that licensees could provide the agency with a reasoned basis for their conclusions that their reactor vessel pressure boundaries would continue to meet regulatory requirements for ensuring the structural integrity of the reactor coolant pressure boundary until the licensees

[13]The Nuclear Energy Institute comprises companies that operate commercial power plants and supports the commercial nuclear industry; and universities, research laboratories, and labor unions affiliated with the nuclear industry. Among other things, it provides a forum to resolve technical and business issues and offers information to its members and policymakers on nuclear issues.

[14]Reactors that were categorized as having already identified cracking or were highly susceptible included Arkansas Nuclear reactor unit 1; D.C. Cook reactor unit 2; Davis-Besse; North Anna reactor units 1 and 2; Oconee reactor units 1, 2 and 3; Robinson reactor unit 2; Surry reactor units 1 and 2; and Three Mile Island reactor unit 1.

[15]NRC, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles" (Bulletin 2001-01, Aug. 8, 2001).

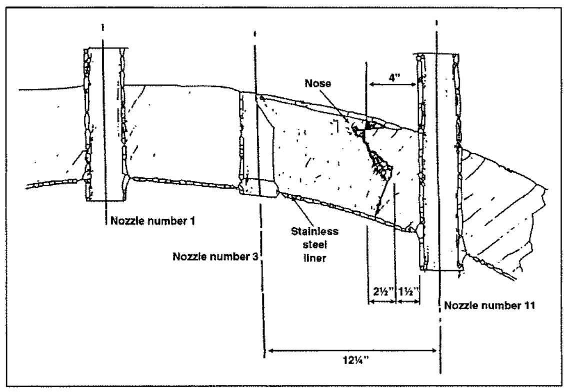
conducted their inspections. NRC used a bulletin, as opposed to a generic letter, to request this information because cracking was considered a significant and urgent issue. All of the licensees of the highly susceptible reactors, except Davis-Besse and D.C. Cook reactor unit 2, provided NRC with plans for conducting inspections by December 31, 2001.[16]

In September 2001, FirstEnergy proposed conducting the requested inspection in April 2002, following its planned March 31, 2002, shutdown to replace fuel. In making this proposal, FirstEnergy contended that the reactor coolant pressure boundary at Davis-Besse met and would continue to meet regulatory requirements until its inspection. NRC and FirstEnergy exchanged information throughout the fall of 2001 regarding when FirstEnergy would conduct the inspection at Davis-Besse. NRC drafted an enforcement order that would have shut down Davis-Besse by December 2001 for the requested inspection in the event that FirstEnergy could not provide an adequate justification for safe operation beyond December 31, 2001, but ultimately compromised on a mid-February 2002 shutdown date. NRC, in deciding when FirstEnergy had to shut down Davis-Besse for the inspection, used a risk-informed decision-making process, including probabilistic risk assessment (PRA), to conclude that the risk that Davis-Besse would have an accident in the interim was relatively low. PRA is an analytical tool for estimating the probability that a potential accident might occur by examining how physical structures, systems, and components, along with employees, work together to ensure plant safety.

Following the mid-February 2002 shutdown and in the course of its inspection in March 2002, FirstEnergy removed about 900 pounds of boric acid crystals and powder from the reactor vessel head, and subsequently discovered three cracked nozzles. The number of nozzles that had cracked, as well as the extent of cracking, was consistent with analyses that NRC staff had conducted prior to the shutdown. However, in examining the extent of cracking, FirstEnergy also discovered that corrosion had caused a pineapple-sized cavity in the reactor vessel head. (See figs. 3 and 4.)

[16]The licensee for D.C. Cook reactor unit 2 proposed to shut down in mid-January 2002 for its inspection. NRC agreed to the delay after crediting D.C. Cook for having been shut down for about a month during the fall of 2001, thus reducing the reactor's operating time.

Figure 3: Diagram of the Cavity in Davis-Besse's Reactor Vessel Head



Source: FirstEnergy.

Figure 4: The Cavity in Davis-Besse's Reactor Vessel Head after Discovery

Source: FirstEnergy.

After this discovery, NRC directed FirstEnergy to, among other things, determine the root cause of the corrosion and obtain NRC approval before restarting Davis-Besse. NRC also dispatched an augmented inspection team consisting of NRC resident, regional, and headquarters officials.[17] The inspection team concluded that the cavity was caused by boric acid corrosion from leaks through the control rod drive mechanism nozzles in the reactor vessel head. Primary water stress corrosion cracking of the nozzles caused through-wall cracks, which led to the leakage and eventual corrosion of the vessel head. NRC's inspection team also concluded, among other things, that this corrosion had gone undetected for an extended period of time—at least 4 years—and significantly compromised the plant's

[17]NRC forms such inspection teams to ensure that the agency investigates significant operational events in a timely, objective, systematic, and technically sound manner, and identifies and documents the causes of such events.

safety margins. As of May 2004, NRC had not yet completed other analyses, including how long Davis-Besse could have continued to operate with the corrosion it had experienced before a vessel head loss-of-coolant accident would have occurred.[18] However, on May 4, 2004, NRC released preliminary results of its analysis of the vessel head and cracked cladding. Based on its analysis of conditions that existed on February 16, 2002, NRC estimated that Davis-Besse could have operated for another 2 to 13 months without the vessel head failing. However, the agency cautioned that this estimate was based on several uncertainties associated with the complex network of cracks on the cladding and the lack of knowledge about corrosion and cracking rates. NRC plans to use this data in preparing its preliminary analysis of how, and the likelihood that, the events at Davis-Besse could have led to core damage. NRC plans to complete this preliminary analysis in the summer of 2004.

NRC also established a special oversight panel to (1) coordinate NRC's efforts to assess FirstEnergy's performance problems that resulted in the corrosion damage, (2) monitor Davis-Besse's corrective actions, and (3) evaluate the plant's readiness to resume operations. The panel, which is referred to as the Davis-Besse Oversight Panel, comprises officials from NRC's Region III office in Lisle, Illinois; NRC headquarters; and the resident inspector office at Davis-Besse. In addition to overseeing FirstEnergy's performance during the shutdown and through restart of Davis-Besse, the panel holds public meetings in Oak Harbor, Ohio, where the plant is located, and nearby Port Clinton, Ohio, to inform the public about its oversight of Davis-Besse's restart efforts and its views on the adequacy of these efforts. The panel developed a checklist of issues that FirstEnergy had to resolve prior to restarting: (1) replacing the vessel head and ensuring the adequacy of other equipment important for safety, (2) correcting FirstEnergy programs that led to the corrosion, and (3) ensuring FirstEnergy's readiness to restart. To restart the plant, FirstEnergy, among other things, removed the damaged reactor vessel head, purchased and installed a new head, replaced management at the plant, and took steps to improve key programs that should have prevented or detected the corrosion. As of March 2004, when NRC gave its approval for Davis-Besse to resume

[18]NRC has an Accident Sequence Precursor Analysis Program to analyze significant events that occur at nuclear power plants to determine how, and the likelihood that, the events could have led to core damage.

operations, the shutdown and preparations for restart had cost FirstEnergy approximately $640 million.[19]

In addition, NRC established a task force to evaluate its regulatory processes for assuring reactor pressure vessel head integrity and to identify and recommend areas for improvement that may be applicable to either NRC or the nuclear power industry. The task force's report, which was issued in September 2002, contains 51 recommendations aimed primarily at improving NRC's process for inspecting and overseeing licensees, communicating with industry, and identifying potential emerging technical issues that could impact plant safety. NRC developed an action plan to implement the report's recommendations.

NRC's Actions to Oversee Davis-Besse Did Not Provide an Accurate Assessment of Safety at the Plant

NRC's inspections and assessments of FirstEnergy's operations should have but did not provide the agency with an accurate understanding of safety conditions at Davis-Besse, and thus NRC failed to identify or prevent the vessel head corrosion. Some NRC inspectors were aware of the indications of corrosion and leakage that could have alerted NRC to corrosion problems at the plant, but they did not have the knowledge to recognize the significance of this information. These problems were compounded by NRC's assessments of FirstEnergy that led the agency to believe FirstEnergy was a good performer and could or would successfully resolve problems before they became significant safety issues. More broadly, NRC had a range of information that could have identified and prevented the incident at Davis-Besse but did not effectively integrate it into its oversight.

[19]FirstEnergy spent about $293 million on operations, maintenance, and capital projects (including $47 million for the new reactor vessel head) and $348 million to purchase power to replace the power that Davis-Besse would have generated over the 2-year shutdown period. In contrast, during a more routine refueling outage, Davis-Besse would spend about $60 million—about $37 million on operations, maintenance, and capital projects and $23 million on replacing the power that would have been generated over a 42-day shutdown period. These latter estimates are based on the Davis-Besse refueling outage in midcalendar year 2000.

Several Factors Contributed to the Inadequacy of NRC's Inspections for Determining Plant Conditions

Three separate, but related, NRC inspection program factors contributed to the development of the corrosion problems at Davis-Besse. First, resident inspectors did not know that the boric acid, rust, and unidentified leaking indicated that the reactor vessel head might be degrading. Second, these inspectors thought they understood the cause for the indications, based on licensee actions to address them. Therefore, resident inspectors, as well as regional and headquarters officials, did not fully communicate information on the indications or decide how to address them, and therefore took no action. Third, because the significance of the symptoms was not fully recognized, NRC did not direct sufficient inspector resources to aggressively investigate the indicators. NRC might have taken a different approach to the Davis-Besse situation if its program to identify emerging issues important to safety had pursued earlier concerns about boric acid corrosion and cracking and recognized how they could affect safety.

Inspectors Did Not Know Safety Significance of Observed Problems

NRC limits the amount of unidentified leakage from the reactor coolant system to no more than 1 gallon per minute. When this limit is exceeded, NRC requires that licensees identify and correct any sources of unidentified leakage. NRC also prohibits any leakage from the reactor coolant pressure boundary, of which the reactor vessel is a key component. Such leakage is prohibited because the pressure boundary is key to maintaining adequate coolant around the reactor fuel and thus protects public health and safety. Because of this, NRC's technical specification states that licensees are to monitor reactor coolant leakage and shut down within 36 hours if leakage is found in the pressure boundary.

In the years leading up to FirstEnergy's March 2002 discovery that Davis-Besse's vessel head had corroded extensively, NRC had several indications of potential leakage problems. First, NRC knew that the rates of leakage in the reactor coolant system had increased. Between 1995 and mid-1998, the unidentified leakage rate was about 0.06 gallon per minute or less, according to FirstEnergy's monitoring. In mid-1998, the unidentified reactor coolant system leakage rate increased significantly—to as much as 0.8 gallon per minute. The elevated leakage rate was dominated by a known problem with a leaking relief valve on the reactor coolant system pressurizer tank, which masked the ongoing leak on the reactor pressure vessel head. However, the elevated leak rate should have raised concerns.

To investigate this leakage, as well as to repair other equipment, FirstEnergy shut down the plant in mid-1999. It then identified a faulty relief valve that accounted for much of the leakage and repaired the valve.

However, after restarting Davis-Besse, the unidentified leakage rate remained significantly higher than the historical average. Specifically, the unidentified leakage rate varied between 0.15 and 0.25 gallon per minute as opposed to the historical low of about 0.06 gallon or less. While NRC was aware that the rate was higher than before, NRC did not aggressively pursue the difference because the rate was well below NRC's limit of no more than 1 gallon per minute, and thus the leak was not viewed as being a significant safety concern. Following the repair in 1999, NRC's inspection report concluded that FirstEnergy's efforts to reduce the leak rate during the outage were effective.

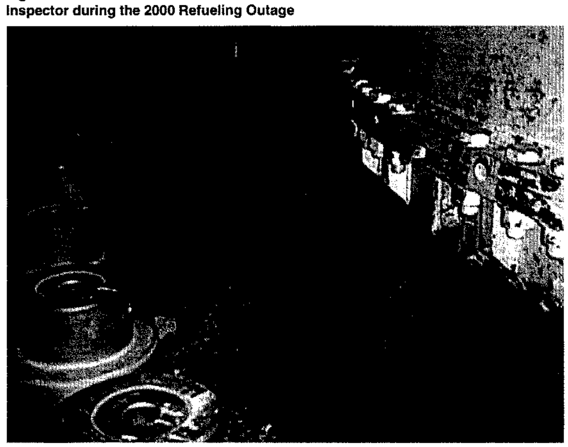
Second, NRC was aware of increased levels of boric acid in the containment building—an indication that components containing reactor coolant were leaking. So much boric acid was being deposited that FirstEnergy officials had to repeatedly clean the containment air cooling system and radiation monitor filters. For example, before 1998, the containment air coolers seldom needed cleaning, but FirstEnergy had to clean them 28 times between late 1998 and May 2001. Between May 2001 and the mid-February 2002 shutdown, the containment air coolers were not cleaned, but at shutdown, FirstEnergy removed 15 5-gallon buckets of boric acid from the coolers—which is almost as much as was found on the reactor pressure vessel head. Rather than seeing these repeated cleanings as an indication of a problem that needed to be addressed, FirstEnergy made cleaning the coolers a routine maintenance activity, which NRC did not consider significant enough to require additional inspections. Furthermore, the radiation monitors, used to sample air from the containment building to detect radiation, typically required new filters every month. However, from 1998 to 2002, these monitors became clogged and inoperable hundreds of times because of boric acid, despite FirstEnergy's efforts to fix the problem.

Third, NRC was aware that FirstEnergy found rust in the containment building. The radiation monitor filters had accumulated dark colored iron oxide particles—a product of carbon steel corrosion—that were likely to have resulted from a very small steam leak. NRC inspection reports during the summer and fall of 1999 noted these indications and, while recognizing FirstEnergy's aggressive attempts to identify the reasons for the phenomenon, concluded that they were a "distraction to plant personnel." Several NRC inspection reports noted indications of leakage, boric acid, and rust before the agency adopted its new Reactor Oversight Process in 2000, but because the leakage was within NRC's technical specifications and NRC officials thought that the licensee understood and would fix the

problem, NRC did not aggressively pursue the indications. NRC's new oversight process, implemented in the spring of 2000, limited the issues that could be discussed in NRC inspection reports to those that the agency considers to have more than minor significance. Because the leakage rates were below NRC's limits, NRC's inspection reports following the implementation of NRC's new oversight process did not identify any discussion of these problems at the plant.

Fourth, NRC was aware that FirstEnergy found rust on the Davis-Besse reactor vessel head, but it did not recognize its significance. For instance, during the 2000 refueling outage, a FirstEnergy official said he showed one of the two NRC resident inspectors a report that included photographs of rust-colored boric acid on the vessel head. (See fig. 5.)

Figure 5: Rust and Boric Acid on Davis-Besse's Vessel Head as Shown to Resident Inspector during the 2000 Refueling Outage



Source: FirstEnergy.

According to this resident inspector, he did not recall seeing the report or photographs but had no reason to doubt the FirstEnergy official's statement. Regardless, he stated that had he seen the photographs, he would not have considered the condition to be significant at the time. He said that he did not know what the rust and boric acid might have indicated, and he assumed that FirstEnergy would take care of the vessel head before restarting. The second resident inspector said he reviewed all such reports at Davis-Besse but did not recall seeing the photographs or this particular report. He stated that it was quite possible that he had read the report, but because the licensee had a plan to clean the vessel head, he would have concluded that the licensee would correct the matter before plant restart. However, FirstEnergy did not accomplish this, even though work orders and subsequent licensee reports indicated that this was done. According to the NRC resident inspector and NRC regional officials, because of the large number of licensee activities that occur during a refueling outage, NRC inspectors do not have the time to investigate or follow up on every issue, particularly when the issue is not viewed as being important to safety. While the resident inspector informed regional officials about conditions at Davis-Besse, the regional office did not direct more inspection resources to the plant, or instruct the resident inspector to conduct more focused oversight. Some NRC regional officials were aware of indications of boric acid corrosion at the plant; others were not. According to the Office of the Inspector General's investigation and 2003 report on Davis-Besse,[20] the NRC regional branch chief—who supervised the staff responsible for overseeing FirstEnergy's vessel head inspection activities during the 2000 refueling outage—said that he was unaware of the boric acid leakage issues at Davis-Besse, including its effects on the containment air coolers and the radiation monitor filters. Had his staff been requested to look at these specific issues, he might have directed inspection resources to that area. (App. I provides a time line showing significant events of interest.)

NRC Did Not Fully Communicate Indications

NRC was not fully aware of the indications of a potential problem at Davis-Besse because NRC's process for transmitting information from resident inspectors to regional offices and headquarters did not ensure that information was fully communicated, evaluated, or used. NRC staff communicated information about plant operations through inspection reports, licensee assessments, and daily conference calls that included

[20]NRC, Office of the Inspector General, *NRC's Oversight of Davis-Besse during the April 2000 Refueling Outage* (Washington, D.C.: Oct. 17, 2003).

resident, regional, and headquarters officials. According to regional officials, information that is not considered important is not routinely communicated to NRC management and technical specialists. For example, while the resident inspectors at Davis-Besse knew all of the indications of leakage, and there was some level of knowledge about these indications at the regional office level, the knowledge was not sufficiently widespread within NRC to alert a technical specialist who might have recognized their safety significance. According to NRC Region III officials, the region uses an informal means—memorandums sent to other regions and headquarters—of communicating information identified at plants that it considers to be important to safety. However, because the indications at Davis-Besse were not considered important, officials did not transmit this information to headquarters. Further, because the process is informal, these officials said they did not know whether—and if so, how—other NRC regions or headquarters used this information.

Similarly, NRC officials said that NRC headquarters had no systematic process for communicating information, such as on boric acid corrosion, cracking, and small amounts of unidentified leakage, that had not yet risen to a relatively high level of concern within the agency, in a timely manner to its regions or on-site inspectors. For example, the regional inspector that oversaw FirstEnergy's activities during the 2000 refueling outage, including the reactor vessel head inspection, stated that he was not aware of NRC's generic bulletins and letters pertaining to boric acid and corrosion, even though NRC issues only a few of these bulletins and generic letters each year.[21] In addition, according to NRC regional officials and the resident inspector at Davis-Besse, there is little time to review technical reports about emerging safety issues that NRC compiles because they are too lengthy and detailed. Ineffective communication, both within the region and between NRC headquarters and the region, was a primary factor cited by NRC's Office of the Inspector General in its investigation of NRC's oversight of Davis-Besse boric acid leakage and corrosion.[22] For example, it found that ineffective communication resulted in senior regional management being largely unaware of repeated reports of boric acid leakage at Davis-Besse. It also found that headquarters, in communications with the regions, did not emphasize the issues discussed in its generic

[21]Over the last 10 years, NRC has issued an average of about two generic bulletins and about four generic letters a year.

[22]NRC, Office of the Inspector General, *NRC's Oversight of Davis-Besse during the April 2000 Refueling Outage* (Washington, D.C.; Oct. 17, 2003).

letters or bulletins on boric acid corrosion or cracking. NRC programs for informing its inspectors about issues that can reduce safety at nuclear power plants were not effective. As a result, NRC inspectors did not recognize the significance of the indications at Davis-Besse, fully communicate information about the indications, or spend additional effort to follow up on the indications.

Resource Constraints Affected NRC Oversight

NRC also did not focus on the indications that the vessel head was corroding because of several staff constraints. Region III was directing resources to other plants that had experienced problems throughout the region, and these plants thus were the subject of increased regulatory oversight. For example, during the refueling outages in 1998 and 2000, while NRC oversaw FirstEnergy's inspection of the reactor vessel head, the region lacked senior project engineers to devote to Davis-Besse. A vacancy existed for a senior project engineer responsible for Davis-Besse from June 1997 until June 1998, except for a one month period, and from September 1999 until May 2000, which resulted in fewer inspection hours at the facility than would have been normal. Other regional staff were also occupied with other plants in the region that were having difficulties, and NRC had unfilled vacancies for resident and regional inspector positions that strained resources for overseeing Davis-Besse.

Even if the inspector positions had been filled, it is not certain that the inspectors would have aggressively followed up on any of the indications. According to our discussions with resident and regional inspectors and our on-site review of plant activities, because nuclear power plants are so large, with many physical structures, systems, and components, an inspector could miss problems that were potentially significant for safety. Licensees typically prepare several hundred reports per month for identifying and resolving problems, and NRC inspectors have only a limited amount of time to follow up on these licensee reports. Consequently, NRC selects and oversees the most safety significant structures, systems, and components.

NRC's Assessment Process Did Not Indicate Deteriorating Performance

Under NRC's Reactor Oversight Process, NRC assesses licensees' performance using two distinct types of information: (1) NRC's inspection results and (2) performance indicators reported by the licensees. These indicators, which reflect various aspects of a plant's operations, include data on, for example, the failure or unavailability of certain important operating systems, the number of unplanned power changes, and the amount of reactor coolant system leakage. NRC evaluates both the inspection results and the performance indicators to arrive at licensee

assessments, which it then color codes to reflect their safety significance. Green assessments indicate that performance is acceptable, and thus connote a very low risk significance and impact on safety. White, yellow, and red assessments each represent a greater degree of safety significance. After NRC adopted its Reactor Oversight Process in April 2000, FirstEnergy never received anything but green designations for its operations at Davis-Besse and was viewed by NRC as a good performer until the 2002 discovery of the vessel head corrosion.[23] Similarly, prior to adopting the Reactor Oversight Process, NRC consistently assessed FirstEnergy as generally being a good performer. NRC officials stated, however, that significant issues were identified and addressed as warranted throughout this period, such as when the agency took enforcement action in response to FirstEnergy's failure to properly repair important components in 1999—a failure caused by weaknesses in FirstEnergy's boric acid corrosion control program.

Key Davis-Besse programs for ensuring the quality and safe operation of the plant's engineered structures, systems, and components include, for example,

- a corrective action program to ensure that problems at the plant that are relevant to safety are identified and resolved in a timely manner,
- an operating experience program to ensure that experiences or problems that occur are appropriately identified and analyzed to determine their significance and relevance to operations, and
- a plant modification program to ensure that modifications important to safety are implemented in a timely manner.

As at other commercial nuclear power plants, NRC conducted routine, baseline inspections of Davis-Besse to determine the effectiveness of these programs. Reports documenting these inspections noted incidences of boric acid leakage, corrosion, and deposits. However, between February 1997 and March 2000, the regional office's assessment of the licensee's performance addressed leakage in the reactor coolant system only once and never noted the other indications. Furthermore, Davis-Besse was not

[23]Before adopting the Reactor Oversight Process, NRC also assessed licensee performance based on inspection results and other information; however, NRC did not assign color codes to assessment results.

the subject of intense scrutiny in regional plant assessment meetings because plants perceived as good performers—such as Davis-Besse—received substantially less attention. Between April 2000—when NRC's revised assessment process took effect—until the corrosion was discovered in March 2002, none of NRC's assessments of Davis-Besse's performance noted leakage or other indications of corrosion at the plant. As a result, NRC may have missed opportunities to identify weaknesses in the Davis-Besse programs intended to detect or prevent the corrosion.

After the corrosion was discovered, NRC analyzed the problems that led to the corrosion on the reactor vessel head and concluded that FirstEnergy's programs for overseeing safety at Davis-Besse were weak, as seen in the following examples:

- Davis-Besse's corrective action program did not result in timely or effective actions to prevent indications of leakage from reoccurring in the reactor coolant system.
- FirstEnergy officials did not always enter equipment problems into the corrective action program because individuals who had identified the problem were often responsible for resolving it.
- For over a decade, FirstEnergy had delayed plant modifications to its service structure platform, primarily because of cost. These modifications would have improved its ability to inspect the reactor vessel head nozzles. As a result, FirstEnergy could conduct only limited visual inspections and cleaning of the reactor pressure vessel head through the small "mouse-holes" that perforated the service structure.

NRC was also unaware of the extent to which various aspects of FirstEnergy's safety culture had degraded—that is, FirstEnergy's organization and performance related to ensuring safety at Davis-Besse. This degradation had allowed the incident to occur with no forewarning because NRC's inspections and performance indicators do not directly assess safety culture. Safety culture is a group of characteristics and attitudes within an organization that establish, as an overriding priority, that issues affecting nuclear plant safety receive the attention their significance warrants. Following FirstEnergy's March 2002 discovery, NRC found numerous indications that FirstEnergy emphasized production over plant safety. First, Davis-Besse routinely restarted the plant following an outage, even though reactor pressure vessel valves and control rod drive mechanisms leaked. Second, staff was unable to remove all of the boric

acid deposits from the reactor pressure vessel head because FirstEnergy's schedule to restart the plant dictated the amount of work that could be performed. Third, FirstEnergy management was willing to accept degraded equipment, which indicated a lack of commitment to resolve issues that could potentially compromise safety. Fourth, Davis-Besse's program that was intended to ensure that employees feel free to raise safety concerns without fear of retaliation had several weaknesses. For example, in one instance, a worker assigned to repair the containment air conditioner was not provided a respirator in spite of his concerns that he would inhale boric acid residue. According to NRC's lessons-learned task force report, NRC was not aware of weaknesses in this program because its inspections did not adequately assess it.

Given that FirstEnergy concluded that one of the causes for the Davis-Besse incident was human performance and management failures, the panel overseeing FirstEnergy's efforts to restart Davis-Besse requested that FirstEnergy assess its safety culture before allowing the plant to restart. To oversee FirstEnergy's efforts to improve its safety culture, NRC (1) reviewed whether FirstEnergy had adequately identified all of the root causes for management and human performance failures at Davis-Besse, (2) assessed whether FirstEnergy had identified and implemented appropriate corrective actions to resolve these failures, and (3) assessed whether FirstEnergy's corrective actions were effective. As late as February 2004, NRC had concerns about whether FirstEnergy's actions would be adequate in the long term. As a result, the Davis-Besse safety culture was one of the issues contributing to the delay in restarting the plant. In March 2004, NRC's panel concluded that FirstEnergy's efforts to improve its safety culture were sufficient to allow the plant to restart. In doing so, however, NRC officials stated that one of the conditions the panel imposed was for FirstEnergy to conduct an independent assessment of the safety culture at Davis-Besse annually over the course of the next 5 years.

NRC Did Not Effectively Incorporate Long-Standing Knowledge about Corrosion, Nozzle Cracking, and Leak Detection into Its Oversight

NRC has been aware of boric acid corrosion and its potential to affect safety since at least 1979. It issued several notices to the nuclear power industry about boric acid corrosion and, specifically, the potential for it to degrade the reactor coolant pressure boundary. In 1987, two licensees found significant corrosion on their reactor pressure vessel heads, which heightened NRC's concern. A subsequent industry study concluded that concentrated solutions of boric acid could result in unacceptably high corrosion rates—up to 4 inches per year—when primary coolant leaks onto surfaces and concentrates at temperatures found on the surface of the

reactor vessel.[24] After considering this information and several more instances of boric acid corrosion at plants, NRC issued a generic letter in 1988 requesting licensees to implement boric acid corrosion control programs.

In 1990, NRC visited Davis-Besse to assess the adequacy of the plant's boric acid corrosion control program. At that time, NRC concluded that the program was acceptable. However, in 1999, NRC became aware that FirstEnergy's boric acid corrosion control program was inadequate because boric acid had corroded several bolts on a valve, and NRC issued a violation. As a result of the violation, FirstEnergy agreed to review its boric acid corrosion procedures and enhance its program. NRC inspectors evaluated FirstEnergy's completed and planned actions to improve the boric acid corrosion control program and found them to be adequate. According to NRC officials, they never inspected the remaining actions—assuming that the planned actions had been implemented effectively. In 2000, NRC adopted its new Reactor Oversight Process and discontinued its inspection procedure for plants' corrosion control programs because these inspections had rarely been conducted due to higher priorities. Thus, NRC had no reliable or routine way to ensure that the nuclear power industry fully implemented boric acid corrosion control programs.

NRC also did not routinely review operating experiences at reactors, both in the United States and abroad, to keep abreast of boric acid developments and determine the need to emphasize this problem. Indeed, NRC did not fully understand the circumstances in which boric acid would result in corrosion, rather than flash to steam. Similarly, NRC did not know the rate at which carbon steel would corrode under different conditions. This lack of knowledge may be linked to shortcomings in its program to review operating experiences at reactors, which could have been exacerbated by the 1999 elimination of the office specifically responsible for reviewing operating experiences.[25] This office was responsible for, among other things, (1) coordinating operational data collection, (2)

[24]Westinghouse Electric Company, *Corrosion Effects of Boric Acid Leakage on Steel under Plant Operating Conditions—A Review of Available Data* (Pittsburgh: October 1987).

[25]NRC's Office for Analysis and Evaluation of Operating Data was established in response to a recommendation that we made to the agency in 1978 that it have a systematic process for analyzing operating experience and feeding this information back to licensees and the industry. NRC eliminated this office, and its responsibilities were transferred to other NRC offices in an effort to gain efficiencies.

systematically analyzing and evaluating operational experience, (3) providing feedback on operational experience to improve safety, (4) assessing the effectiveness of the agencywide program, and (5) acting as a focal point for interaction with outside organizations on issues pertaining to operational safety data analysis and evaluation. According to NRC officials who had overseen Davis-Besse at the time of the incident, they would not have suspected the reactor vessel head or cracked head penetration nozzles as the source of the filter clogging and unidentified leakage because they had not been informed that these could be potential problems. According to these officials, the vessel head was "not on the radar screen."

With regard to nozzle cracking, NRC, for more than two decades, was aware of the potential for nozzles and other components made of alloy 600 to crack. While cracks were found at nuclear power plants, NRC considered their safety significance to be low because the cracks were not developing rapidly. In contrast, other countries considered the safety significance of such cracks to be much higher. For example, concern over alloy 600 cracking led France, as a preventive measure, to institute requirements for an extensive nondestructive examination inspection program for vessel head penetration nozzles, including the removal of insulation, during every fuel outage. When any indications of cracking were observed, even more frequent inspections were required, which, because of economic considerations, resulted in the replacement of vessel heads when indications were found. The effort to replace the vessel heads is still under way. Japan replaced those vessel heads whose nozzles it considered most susceptible to cracking, even though no cracks had yet been found. Both France and Sweden also installed enhanced leakage monitoring systems to detect leaks early. However, according to NRC, such systems cannot detect the small amounts of leakage that may be typical from cracked nozzles.

NRC recognized that an integrated, long-term program, including periodic inspections and monitoring of vessel heads to check for nozzle cracking, was necessary. In 1997, it issued a generic letter that summarized NRC's efforts to address cracking of control rod drive mechanism nozzles and requested information on licensees' plans to inspect nozzles at their reactors. More specifically, this letter asked licensees to provide NRC with descriptions of their inspections of these nozzles and any plans for enhanced inspections to detect cracks. At that time, NRC was planning to review this information to determine if enhanced licensee inspections were warranted. Based on its review of this information, NRC concluded that the current inspection program was sufficient. As a result, between 1998 and

2001, NRC did not issue or solicit additional information on nozzle cracking or assess its requirements for inspecting reactor vessels to determine whether they were sufficient to detect cracks. At Davis-Besse, NRC also did not determine if FirstEnergy had plans or was implementing any plans for enhanced nozzle inspections, as noted in the 1997 generic letter. NRC took no further action until the cracks were found in 2001 at the Oconee plant, in South Carolina. NRC attributed its lack of focus on nozzle cracking, in part, to the agency's inability to effectively review, assess, and follow up on industry operating experience events. Furthermore, as with boric acid corrosion, NRC did not obtain or analyze any new data about cracking that would have supported making changes in either its regulations or inspections to better identify or prevent corrosion on the vessel head at Davis-Besse.

NRC's technical specifications regarding allowable leakage rates also contributed to the corrosion at Davis-Besse because the amount of leakage that can cause extensive corrosion can be significantly less than the level that NRC's specifications allow. According to NRC officials, NRC's requirements, established in 1973, were based on the best available technology at that time. The task of measuring identified and unidentified leakage from the reactor coolant system is not precise. It requires licensees to estimate the amount of coolant that the reactor is supposed to contain and identify any difference in coolant levels. They then have to account for the estimated difference in the actual amount of coolant to arrive at a leakage rate; to do this, they identify all sources and amounts of leakage by, among other things, measuring the amount of water contained in various sump collection systems. If these sources do not account for the difference, licensees know they have an unidentified source of leakage. This estimate can vary significantly from day to day between negative and positive numbers.

According to analyses that FirstEnergy conducted after it identified the corrosion in March 2002, the leakage rates from the nozzle cracks were significantly below NRC's reactor coolant system unidentified leakage rate of 1 gallon per minute. Specifically, the leakage from the nozzle around which the vessel head corrosion occurred was predicted to be 0.025 gallon per minute. If such small leakage can result in such extensive corrosion, identifying if and where such leakage occurs is important. NRC staff recognized as early as 1993 it would be prudent for the nuclear power industry to consider implementing an enhanced method for detecting small leaks during plant operation, but NRC did not require this action, and the industry has not taken steps to do so. Furthermore, NRC has not

consistently enforced its requirement for reactor coolant pressure boundary leakage. As a result, the NRC Davis-Besse task force concluded that inconsistent enforcement may have reinforced a belief that alloy 600 nozzle leakage was not actually or potentially a safety significant issue.

NRC's Process for Deciding Whether to Allow a Delayed Davis-Besse Shutdown Lacked Credibility

Although FirstEnergy operated Davis-Besse without incident until shutting it down in February 2002, certain aspects of NRC's deliberations allowing the delayed shutdown raise questions about the credibility of the agency's decision making, if not about the Davis-Besse decision itself. NRC does not have specific guidance for deciding on plant shutdowns. Instead, agency officials turned to guidance developed for a different purpose—reviewing requests to amend license operating conditions—and even then did not always adhere to this guidance. In addition, NRC did not document its decision-making process, as called for by its guidance, and its letter to FirstEnergy to lay out the basis for the decision—sent a year after the decision—did not fully explain the decision. NRC's lack of guidance, coupled with the lack of documentation, precludes us from independently judging whether NRC's decision was reasonable. Finally, some NRC officials stated that the shutdown decision was based, in part, on the agency's probabilistic risk assessment (PRA) calculations of the risk that Davis-Besse would pose if it delayed its shutdown and inspection. However, as noted by our consultants, the calculations were flawed, and NRC's decision makers did not always follow the agency's guidance for developing and using such calculations.

NRC Did Not Have Specific Guidance for Deciding on Plant Shutdowns

NRC believed that Davis-Besse could have posed a potential safety risk because it was, in all likelihood, failing to comply with NRC's technical specification that no leakage occur in the reactor coolant pressure boundary. Its belief was based on the following indicators of probable leakage:

- All six of the other reactors manufactured by the same company as Davis-Besse's reactor had cracked nozzles and identified leakage.[26]
- Three of these six reactors had identified circumferential cracking.

[26]Davis-Besse's manufacturer was the Babcock and Wilcox Company, which is an operating unit of McDermott International.

- FirstEnergy had not performed a recent visual examination of all of its nozzles.

Furthermore, a FirstEnergy manager agreed that cracks and leakage were likely.

NRC has the authority to shut down a plant when it is clear that the plant is in violation of important safety requirements, and it is clear that the plant poses a risk to public health and safety.[27] Thus, if a licensee is not complying with technical specifications, such as those for no allowable reactor vessel pressure boundary leakage, NRC can order a plant to shut down. However, NRC decided that it could not require Davis-Besse to shut down on the basis of other plants' cracked nozzles and identified leakage or the manager's acknowledgement of a probable leak. Instead, it believed it needed more direct, or absolute, proof of a leak to order a shutdown. This standard of proof has been questioned. According to the Union of Concerned Scientists,[28] for example, if NRC needed irrefutable proof in every case of suspected problems, the agency would probably never issue a shutdown order. In effect, in this case NRC created a Catch-22: It needed irrefutable proof to order a shutdown but could not get this proof without shutting down the plant and requiring that the reactor be inspected.

Despite NRC's responsibility for ensuring that the public is adequately protected from accidents at commercial nuclear power plants, NRC does not have specific guidance for shutting down a plant when the plant may pose a risk to public health and safety, even though it may be complying with NRC requirements. It also has no specific guidance or standards for quality of evidence needed to determine that a plant may pose an undue risk. Lacking direct or absolute proof of leakage at Davis-Besse, NRC instead drafted a shutdown order on the basis that a potentially hazardous condition may have existed at the plant. NRC had no guidance for developing such a shutdown order, and therefore, it used its guidance for reviewing license amendment requests. NRC officials recognized that this guidance was not specifically designed to determine whether NRC should shut down a power plant such as Davis-Besse. However, NRC officials

[27]Ordinarily, NRC would not suspend a license for a failure to meet a requirement unless the failure was willful and adequate corrective action had not been taken.

[28]The Union of Concerned Scientists is a nonprofit partnership of scientists and citizens that augments scientific analyses and policy development for identifying environmental solutions to issues such as energy production.

stated that this guidance was the best available for deciding on a shutdown because, although the review was not to amend a license, the factors that NRC needed to consider in making the decision and that were contained in the guidance were applicable to the Davis-Besse situation.

To use its guidance for reviewing license amendment requests, NRC first determined that the situation at Davis-Besse posed a special circumstance because new information revealed a substantially greater potential for a known hazard to occur, even if Davis-Besse was in compliance with the technical specification for leakage from the reactor coolant pressure boundary. The special circumstance stemmed from NRC's determination that requirements for conducting vessel head inspections were not sufficient to detect nozzle cracking and, thus, small leaks.[29] According to NRC officials, this determination allowed NRC to use its guidance for reviewing license amendment requests when deciding whether to order a shutdown.

The Extent of NRC's Reliance on License Amendment Guidance Is Not Clear

Under NRC's license amendment guidance, NRC considers how the license change affects risk, but not how it has previously assessed licensee performance, such as whether the licensee was viewed as a good performer. With regard to the Davis-Besse decision, the guidance directed NRC to determine whether the plant would comply with five NRC safety principles if it operated beyond December 2001 without inspecting the reactor vessel head. As applied to Davis-Besse, these principles were whether the plant would (1) continue to meet requirements for vessel head inspections, (2) maintain sufficient defense-in-depth, (3) maintain sufficient safety margins, (4) have little increase in the likelihood of a core damage accident, and (5) monitor the vessel head and nozzles. The guidance, however, does not specify how to apply these safety principles, how NRC can demonstrate it has followed the principles and ensured they are met, or whether any one principle takes precedence over the others. The guidance also does not indicate what actions NRC or licensees should take if some or all of the principles are not met.

[29]Specifically, reactor vessel head inspection requirements do not require that insulation be removed. Because of this, reactor vessel head inspections performed without removing the insulation above the vessel head could not result in 100 percent of the nozzles being visually inspected.

In mid-September 2001, NRC staff concluded that Davis-Besse complied with the first safety principle but did not meet the remaining four. According to the staff, Davis-Besse did not meet three safety principles because the requirements for vessel head inspections were not adequate. Specifically, the requirements do not require the inspector to remove the insulation above the vessel head, and thus allow all of the nozzles to be visually inspected. NRC therefore could not ensure that FirstEnergy was maintaining defense-in-depth and adequate safety margins or sufficiently monitoring the vessel head and nozzles. The staff believed that Davis-Besse did not meet the fourth safety principle because the risk estimate of core damage approached an unacceptable level and the estimate itself was highly uncertain.

Between early October and the end of November 2001, NRC requested and received additional information from FirstEnergy regarding its risk estimate of core damage—its PRA estimate—and met with the company to determine the basis for the estimate. NRC was also developing its own risk estimate, although its numbers kept changing. At some point during this time, NRC staff also concluded that the first safety principle was probably not being met, although the basis for this conclusion is not known.

At the end of November 2001, NRC contacted FirstEnergy and informed it that a shutdown order had been forwarded to the NRC commissioners and asked if FirstEnergy could take any actions that would persuade NRC to not issue the shutdown order. The following day, FirstEnergy proposed measures to mitigate the potential for and consequences of an accident. These measures included, among other things, lowering the operating temperature from 605 degrees Fahrenheit to 598 degrees Fahrenheit to reduce the driving force for stress corrosion cracking on the nozzles, identifying a specific operator to initiate emergency cooling in response to an accident, and moving the scheduled refueling outage up from March 31, 2002, to no later than February 16, 2002. NRC staff discussed these measures, and NRC management asked the staff if they were concerned about extending Davis-Besse's operations until mid-February 2002. While some of the staff were concerned about continued operations, none indicated to NRC management that cracking in control rod drive mechanism nozzles was likely extensive enough to cause a nozzle to eject from the vessel head, thus making it unsafe to operate. NRC formally accepted FirstEnergy's compromise proposal within several days, thus abandoning its shutdown order.

NRC Did Not Fully Explain or Document the Basis for Its Decision

We could not fully assess NRC's basis for accepting FirstEnergy's proposal. NRC did not document its deliberations, even though its guidance requires that it do so. This documentation is to include the data, methods, and assessment criteria used; the basis for the decisions made; and essential correspondence sufficient to document the persons, places, and matters dealt with by NRC. Specifically, the guidance requires that the documentation contain sufficient detail to make possible a "proper scrutiny" of NRC decisions by authorized outside agencies and provide evidence of how basic decisions were formed, including oral decisions. NRC's guidance also states that NRC should document all important staff meetings.

In reviewing NRC's documentation on the Davis-Besse decision, we found no evidence of an in-depth or formal analysis of how Davis-Besse's proposed measures would affect the plant's ability to satisfy the five safety principles. Thus, it is unclear whether the safety principles contained in the guidance were met by the measures that FirstEnergy proposed. However, several NRC officials stated that FirstEnergy's proposed measures had no impact on plant operations or safety. For example, according to one NRC official, FirstEnergy's proposal to reduce the operating temperature would have had little impact on safety because the small drop in operating temperature over a 7-week period would have had little effect on the growth rate of any cracks in a nozzle. As such, this official considered the measures as "window dressing." A proposed measure that NRC staff did consider as having a significant impact on the risk was for FirstEnergy to dedicate an operator for manually turning on safety equipment in the event that a nozzle was ejected. Subsequent to approving the delayed shutdown, NRC learned that FirstEnergy had not, in fact, planned to dedicate an operator for this task—rather, FirstEnergy planned to have an operator do this task in addition to other regularly assigned duties.

According to an NRC official, once NRC decided not to issue a shutdown order for December 2001, NRC staff needed to discuss how NRC's assessment of whether the five safety principles had been met had changed in the course of the staff's deliberations. However, there was no evidence in the agency's records to support that this discussion was held, and other key meetings, such as the one in which the agency made its decision to allow Davis-Besse to operate past December 31, 2001, were not documented. Without documentation, it is not clear what factors influenced NRC's decision. For example, according to the NRC Office of the Inspector General's December 2002 report that examined the Davis-Besse incident, NRC's decision was driven in large part by a desire to lessen the financial

impact on FirstEnergy that would result from an early shutdown.[30] While NRC disputed this finding, we found no evidence in the agency's records to support or refute its position.

In December 2001, when NRC informed FirstEnergy that it accepted the company's proposed measures and the February 16, 2002, shutdown date, it also said that the company would receive NRC's assessment in the near future. However, NRC did not provide the assessment until a full year later—in December 2002. In addition, the December 2002 assessment, which includes a four-page evaluation, does not fully explain how the safety principles were used or met—other than by stating that if the likelihood of nozzle failure were judged to be small, then adequate protection would be ensured. Even though NRC's regulations regarding the reactor coolant pressure boundary dictate that the reactor have an extremely low probability of failing, NRC stated it did not believe that Davis-Besse needed to demonstrate strict conformance with this regulation. As evidence of the small likelihood of failure, NRC cited the small size of cracks found at other power plants, as well as its preliminary assessment of nozzle cracking, which projected crack growth rates. NRC concluded that 7 weeks of additional operation would not result in an appreciable increase in the size of the cracks.[31] While NRC included its calculated estimates of the risk that Davis-Besse would pose, it did not detail how it calculated its estimates.

NRC's PRA Estimate Was Flawed and Its Use in Deciding to Delay the Shutdown Is Unclear

In moving forward with its more risk-informed regulatory approach, NRC has established a policy to increase the use of PRA methods as a means to promote regulatory stability and efficiency. Using PRA methods, NRC and the nuclear power industry can estimate the likelihood that different accident scenarios at nuclear power plants will result in reactor core damage and a release of radioactive materials. For example, one of these accident scenarios begins with a "medium break" loss-of-coolant accident in which the reactor coolant system is breached and a midsize—about 2- to 4-inch—hole is formed that allows coolant to escape from the reactor

[30]NRC, Office of the Inspector General, *NRC's Regulation of Davis-Besse Regarding Damage to the Reactor Vessel Head* (Washington, D.C.; Dec. 30, 2002).

[31]NRC, *Preliminary Staff Technical Assessment for Pressurized Water Reactor Vessel Head Penetration Nozzles Associated with NRC Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles"* (Washington, D.C.; Nov. 6, 2001).

pressure boundary. The probability of such an accident scenario occurring and the consequences of that accident take into account key engineering safety system failure rates and human error probabilities that influence how well the engineered systems would be able to mitigate the consequences of an accident and ensure no radioactive release from the plant.

For Davis-Besse, NRC needed two estimates: one for the frequency of a nozzle ejecting and causing a loss-of-coolant accident and one for the probability that a loss-of-coolant accident would result in core damage. NRC first established an estimate, based partially on information provided by FirstEnergy, for the frequency of a plant developing a cracked nozzle that would initiate a medium break loss-of-coolant accident. NRC estimated that the frequency of this occurring would be about $2x10^{-2}$, or 1 chance in 50,[32] per year. NRC then used an estimate, which FirstEnergy provided, for the probability of core damage given a medium break loss-of-coolant accident. This probability estimate was $2.7x10^{-3}$, or about 1 chance in 370.[33] Multiplying these two numbers, NRC estimated that the potential for a nozzle to crack and cause a loss-of-coolant accident would increase the frequency of core damage at Davis-Besse by about $5.4x10^{-5}$ per year, or about 1 in 18,500 per year.[34] Converting this frequency to a probability associated with continued operation for 7 weeks, NRC calculated that the increase in the probability of core damage was approximately $5x10^{-6}$, or 1 chance in 200,000.[35] While NRC officials currently disagree that this was the number it used, this is the number that it included in its December 2002 assessment provided to FirstEnergy. Further, we found no evidence in the agency's records to support NRC's current assertion.

According to our consultants, the way NRC calculated and used the PRA estimate was inadequate in several respects. (See app. II for the consultants' detailed report.) First, NRC's calculations did not take into

[32]Here is how to calculate the frequency estimate: $2x10^{-2}$ equates to 0.02, or 2/100, which equals 1/50.

[33]Here is how to calculate the probability estimate: $2.7x10^{-3}$ equates to 0.0027, or 27/10,000, which equals 1/370.37.

[34]Here is how to calculate the frequency estimate: $5.4x10^{-5}$ equates to 0.000054, or 54/1,000,000, which equals 1/18,518.52.

[35]Here is how to calculate the probability estimate: $5x10^{-6}$ equates to 0.000005, or 5/1,000,000, which equals 1/200,000.

account several factors, such as the possibility of corrosion and axial cracking that could lead to leakage. For example, the consultants concluded that NRC's estimate of risk was incorrectly too small, primarily because the calculation did not consider corrosion of the vessel head. In reviewing how NRC developed and used its PRA estimates for Davis-Besse, our consultants noted that the calculated risk was smaller than it should have been because the calculations did not consider corrosion of the reactor vessel from the boric acid coolant leaking through cracks in the nozzles. According to the consultants, apparently all NRC staff involved in the Davis-Besse decision were aware that coolant under high pressure was leaking from valves, flanges, and possibly from cracks but evidently thought that the coolant would immediately flash into steam and noncorrosive compounds of boric acid. Our consultants, however, stated that because boric acid could potentially cause corrosion, except at temperatures much higher than 600 degrees Fahrenheit, NRC should have anticipated that corrosion could occur. Our consultants further stated that as evaporation occurs, boric acid becomes more concentrated in the remaining liquid—making it far more corrosive—and as vapor pressure decreases, evaporation is further slowed. They said it should be expected that some of the boric acid in the escaping coolant could reach the metal surfaces as wet or moist, highly corrosive material underlying the surface layers of dry noncorrosive boric acid, which is evidently what happened at Davis-Besse.

Our consultants concluded that NRC staff should have been aware of the experience at French nuclear power plants, where boric acid corrosion from leaking reactor coolant had been identified during the previous decade, the safety significance had been recognized, and safety procedures to mitigate the problem had been implemented. Furthermore, tests had been conducted by the nuclear power industry and in government laboratories on boric acid corrosion that were widely available to NRC. They stated that keeping abreast of safety issues at similar plants, whether domestic or foreign, and conveying relevant safety information to licensees are important functions of NRC's safety program. According to NRC, the agency was aware of the experience at French nuclear power plants. For example, NRC concluded, in a December 15, 1994, internal NRC memo, that primary coolant leakage from a through-wall crack could cause boric acid corrosion of the vessel head. However, because it concluded that some analyses indicated that it would take at least 6 to 9 years before any corrosion would challenge the structural integrity of the head, NRC concluded that cracking was not a short-term safety issue.

Our consultants also stated that NRC's risk analysis was inadequate because the analysis concerned only the formation and propagation of circumferential cracks that could result in nozzle failure, loss of coolant, and even control rod ejection. Although there is less chance of axial cracks causing complete nozzle failure, these cracks open additional pathways for coolant leakage. In addition, their long crevices provide considerably greater opportunity for the coolant to concentrate near the surface of the vessel head. However, according to our consultants, NRC was convinced that the boric acid they saw resulted from leaking flanges above the reactor vessel head, as opposed to axial cracks in the nozzles.

Second, NRC's analysis was inadequate because it did not include the uncertainty of its risk estimate and use the uncertainty analysis in the Davis-Besse decision-making process, although NRC staff should have recognized large uncertainties associated with its risk estimate. Our consultants also concluded that NRC failed to take into account the large uncertainties associated with estimates of the frequency of core damage resulting from the failure of nozzles. PRA estimates for nuclear power plants are subject to significant uncertainties associated with human errors and other common causes of system component failures, and it is important that proper uncertainty analyses be performed for any PRA study. NRC guidance and other NRC reports on advancing PRA technology for risk-informed decisions emphasize the need to understand and characterize uncertainties in PRA estimates. Our consultants stated that had the NRC staff estimated the margin of error or uncertainty associated with its PRA estimate for Davis-Besse, the uncertainty would likely have been so high as to render the estimate of questionable value.

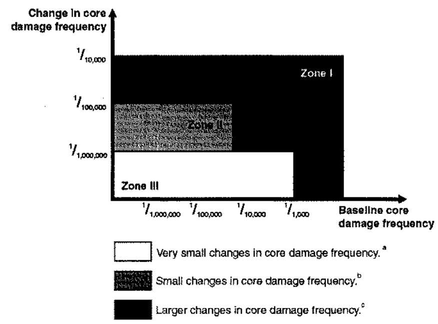
Third, NRC's analysis was inadequate because the risk estimates were higher than generally considered acceptable under NRC guidance. Despite PRA's important role in the decision, our consultants found that NRC did not follow its own guidance for ensuring that the estimated risk was within levels acceptable to the agency. NRC required the nuclear power industry to develop a baseline estimate for how frequently a core damage accident could occur at every nuclear power plant in the United States. This baseline estimate is used as a basis for deciding whether changes at a plant that affect the core damage frequency are acceptable. The baseline core damage frequency estimate for the Davis-Besse plant was between $4x10^{-5}$

and 6.6×10^{-5} per year (which is between 1 chance in 25,000[36] per year and about 1 chance in 15,150[37] per year). NRC guidance for reviewing and approving license amendment requests indicates that any plant-specific change resulting in an increase in the frequency of core damage of 1×10^{-5} per year (which is 1 chance in 100,000 per year) or more would fall within the highest risk zone: In this case, NRC would generally not approve the change because the risk criterion would not be met. If a license change would result in a core damage frequency change of 1×10^{-5} per year to 1×10^{-6} per year (which is 1 chance in 100,000 per year to 1 chance in 1 million per year), the risk criterion would be considered marginally met and NRC would consider approving the change but would require additional analysis. Finally, if a license change would result in a core damage frequency change of 1×10^{-6} per year (which is 1 chance in 1 million per year) or less, the risk would fall within the lowest risk zone and NRC would consider the risk criterion to be met and would generally consider approving the change without requiring additional analysis. (See fig. 6.)

[36]Here is how to calculate the frequency estimate: 4×10^{-5} equates to 0.00004, or 4/100,000, which equals 1/25,000.

[37]Here is how to calculate the frequency estimate: 6.6×10^{-5} equates to 0.000066, or 66/1,000,000, which equals 1/15,151.51.

Figure 6: NRC's Acceptance Guidelines for Core Damage Frequency



Source: NRC.

[a]Risk criterion is met and license changes would generally be considered.

[b]Risk criterion is considered marginally met and while license changes are generally considered, they require additional analysis.

[c]Risk criterion is not met and license changes are generally not allowed.

However, NRC's PRA estimate for Davis-Besse—an increase in the frequency of core damage of $5.4x10^{-5}$, or 1 chance in about 18,500 per year—was higher than the acceptable level. While an NRC official who helped develop the risk estimate said that additional NRC and industry guidance was used to evaluate whether its PRA estimate was acceptable, this guidance also suggests that NRC's estimate was too high. NRC's estimate of the increase in the frequency of core damage of $5.4x10^{-5}$ per year equates to an increase in the probability of core damage of $5x10^{-6}$, or 1 chance in 200,000, for the 7-week period December 31, 2001, to February 16, 2002.[35] NRC's guidance for evaluating requests to relax NRC technical specifications suggests that a probability increase higher than $5x10^{-7}$, or 1 chance in 2 million[38], is considered unacceptable for relaxing the specifications. Thus, NRC's estimate would not be considered acceptable

[38]Here is how to calculate the probability estimate: $5x10^{-7}$ equates to 0.0000005, or 5/10,000,000, which equals 1/2,000,000.

under this guidance. NRC's estimate would also not be considered acceptable under Electric Power Research Institute or Nuclear Energy Institute guidance unless further action were taken to evaluate or manage risk. According to NRC officials, NRC viewed its PRA estimate as being within acceptable bounds because it was a temporary situation—7 weeks—and NRC had, at other times, allowed much higher levels of risk at other plants. However, at the time that NRC made its decision, it did not document the basis for accepting this risk estimate, even though NRC's guidance explicitly states that the decision on whether PRA results are acceptable must be based on a full understanding of the contributors to the PRA results and the reasoning must be well documented. In defense of its decision, NRC officials said that the process they used to arrive at the decision is used to make about 1,500 licensing decisions such as this each year.

Lastly, NRC's analysis was inadequate because the agency does not have clear guidance for how PRA estimates are to be used in the decision-making process. Our consultants concluded that NRC's process for risk-informed decision making is ill-defined, lacks guidelines for how it is supposed to work, and is not uniformly transparent within NRC. According to NRC officials involved in the Davis-Besse decision, NRC's guidance is not clear on the use of PRA in the decision-making process. For example, while NRC has extensive guidance, this guidance does not outline to what extent or how the resultant PRA risk number and uncertainty should be weighed with respect to the ultimate decision. One factor complicating this issue is the lack of a predetermined methodology to weigh risks expressed in PRA numbers against traditional deterministic results and other factors.[39] Absent this guidance, the value assigned to the PRA analysis is largely at the discretion of the decision maker. The process, which NRC stated is robust, can result in a decision in which PRA played no role, a partial role, or one in which it was the sole deciding factor. According to our consultants, this situation is made worse by the lack of guidelines for how, or by whom, decisions in general are made at NRC.

It is not clear how NRC staff used the PRA risk estimate in the Davis-Besse decision-making process. For example, according to one NRC official who

[39]The deterministic approach considers a set of safety challenges and how those challenges should be mitigated through engineering safety margins and quality assurance standards. The probabilistic approach extends this by allowing for the consideration of a broader set of safety challenges, prioritizing safety challenges based on risk significance, and allowing for a broader set of mitigation mechanisms.

was familiar with some of the data on nozzle cracking, these data were not sufficient for making a good probabilistic decision. He stated that he favored issuing an order requiring that Davis-Besse be shut down by the end of December 2001 because he believed the available data were not sufficient to assure a low enough probability for a nozzle to be ejected. Other officials indicated that they accepted FirstEnergy's proposed February 16, 2002, shutdown date based largely on NRC's PRA estimate for a nozzle to crack and be ejected. According to one of these officials, allowing the additional 7 weeks of operating time was not sufficiently risk significant under NRC's guidance. He stated that safety margins at the plant were preserved and the PRA number was within an acceptable range. Still another official said he discounted the PRA estimate and did not use it at all when recommending that NRC accept FirstEnergy's compromise proposal. This official also stated that it was likely that many of the staff did base their conclusions on the PRA estimate. According to our consultants, although the extent to which the PRA risk analysis influenced the decision making will probably never be known, it is apparent that it did play an important role in the decision to allow the shutdown delay.

NRC Has Made Progress in Implementing Recommended Changes, but Is Not Addressing Important Systemic Issues

NRC has made significant progress in implementing the actions recommended by the Davis-Besse lessons-learned task force. While NRC has implemented slightly less than half—21 of the 51—recommendations as of March 2004, it is scheduled to have more than 70 percent of them implemented by the end of 2004. For example, NRC has already taken actions to improve staff training and inspections that would appear to help address the concern that NRC inspectors viewed FirstEnergy as a good performer and thus did not subject Davis-Besse to the level of scrutiny or questioning that they should have. It is not certain when actions to implement the remaining recommendations will occur, in part because of resource constraints. NRC also faces challenges in fully implementing the recommendations, also in part because of resource constraints, both in the staff needed to develop specific corrective actions and in the additional staff responsibilities and duties to carry them out. Further, while NRC is making progress, the agency is not addressing three systemic issues highlighted by the Davis-Besse experience: (1) an inability to detect weakness or deterioration in FirstEnergy's safety culture, (2) deficiencies in NRC's process for deciding on a shutdown, and (3) lack of management controls to track, on a longer-term basis, the effectiveness of actions implemented in response to incidents such as Davis-Besse, so that they do not occur at another power plant.

NRC Does Not Expect to Complete Its Actions until 2006, in Part Because of Resource Constraints

NRC's lessons-learned task force for Davis-Besse developed 51 recommendations to address the weaknesses that contributed to the Davis-Besse incident. Of these 51 recommendations, NRC rejected 2 because it concluded that agency processes or procedures already provided for the recommendations' intent to be effectively carried out.[40] To address the remaining 49 recommendations, NRC developed a plan in March 2003 that included, for each recommendation, the actions to be taken, the responsible NRC office, and the schedule for completing the actions. When developing its schedule, NRC placed the highest priority on implementing recommendations that were most directly related to the underlying causes of the Davis-Besse incident as well as those recommendations responding to vessel head corrosion. NRC assigned a lower priority to the remaining recommendations, which were to be integrated into the planning activities of those NRC offices assigned responsibility for taking action on the recommendations. In assigning these differing priorities, NRC officials stated they recognized that the agency has many other pressing matters to address that are not related to the Davis-Besse incident, such as renewing operating licenses, and they did not want to divert resources away from these activities. (App. III contains a complete list of the task force's recommendations, NRC actions, and the status of the recommendations as of March 2004.)

To better track the status of the agency's actions to implement the recommendations, we split two of the 49 recommendations that NRC accepted into 4; therefore, our analysis reflects NRC's response to 51 recommendations. As shown in table 1, as of March 2004, NRC had made progress in implementing the recommendations, although some completion dates have slipped.

[40]These two recommendations were for NRC to (1) review how industry considers economic factors in making decisions to repair equipment and consider these factors in developing guidance for nonvisual inspections of vessel head penetration nozzles, and (2) revise the criteria for reviewing industry topical reports that have not been formally submitted to NRC for review but that have generic safety implications.

Table 1: Status of Davis-Besse Lessons-Learned Task Force Recommendations, as of March 2004

Status	Number of recommendations
Completed as of March 2004	21
Scheduled for completion April through December 2004	17
Scheduled for completion in 2005	6
Completion date yet to be determined	7
Total	**51**

Source: GAO analysis of NRC data.

Note: This table does not include the two recommendations NRC rejected.

As the table shows, as of March 2004, NRC had implemented 21 recommendations and scheduled another 17 for completion by December 2004. However, some slippage has already occurred in this schedule—primarily because of resource constraints—and NRC has rescheduled completion of some recommendations. NRC's time frames for completing the recommendations depend on several factors—the recommendations' priority, the amount of work required to develop and implement actions, and the need to first complete actions on other related recommendations.

Of the 21 implemented recommendations, 10 called upon NRC to revise or enhance its inspection guidance or training. For example, NRC revised the guidance it uses to assess the implementation of licensees' programs to identify and resolve problems before they affect operations. It took this action because the task force had concluded that FirstEnergy's weak corrective action program implementation was a major contributor to the Davis-Besse incident. NRC has also developed Web-based training modules to improve NRC inspectors' knowledge of boric acid corrosion and nozzle cracking. The other 11 completed recommendations concerned actions such as

- collecting and analyzing foreign and domestic information on alloy 600 nozzle cracking,
- fully implementing and revising guidance to better assure that licensees carry out their commitments to make operational changes, and
- establishing measurements for resident inspector staffing levels and requirements.

By the end of 2004, NRC expects to complete another 17 recommendations, 12 of which generally address broad oversight or programmatic issues, and 5 of which provide for additional inspection guidance and training. On the broader issues, for example, NRC is scheduled to complete a review of the effectiveness of its response to past NRC lessons-learned task force reports by April 2004. By December 2004, NRC expects to have a framework established for moving forward with implementing recommended improvements to its agencywide operating experience program.

In 2005, 4 of the 6 recommendations scheduled for completion concern leakage from the reactor coolant system. For example, NRC is to (1) develop guidance and criteria for assessing licensees' responses to increasing leakage levels and (2) determine whether licensees should install enhanced systems to detect leakage from the reactor coolant system. The fifth recommendation calls for NRC to inspect the adequacy of licensees' programs for controlling boric acid corrosion, and the final recommendation calls on NRC to assess the basis for canceling a series of inspection procedures in 2001.

NRC did not assign completion dates to 7 recommendations because, among other things, their completion depends on completing other recommendations or because of limited resources. Even though it has not assigned completion dates for these recommendations, NRC has begun to work on 5 of the 7:

- Two recommendations will be addressed when requirements for vessel head inspections are revised. To date, NRC has taken some related, but temporary, actions. For example, since February 2003, it has required licensees to more extensively examine their reactor vessel heads. NRC has also issued a series of temporary instructions for NRC inspectors to oversee the enhanced examinations. NRC expects to replace these temporary steps with revised requirements for vessel head inspections.

- Two recommendations call upon NRC to revise requirements for detecting leaks in the reactor coolant pressure boundary. In response, NRC has, for example, begun to review its barrier integrity requirements and has contracted for research on enhanced detection capabilities.

- One recommendation is directed at improving follow-up of licensee actions taken in response to NRC generic communications. NRC is currently developing a temporary inspection procedure to assess the effectiveness of licensee actions taken in response to generic

communications. Additionally, as a long-term change in the operating experience program, the agency plans to improve the verification of how effective its generic communications are.

The remaining two recommendations address NRC's need to (1) evaluate the adequacy of methods for analyzing the risks posed by passive components, such as reactor vessels, and integrate these methods and risks into NRC's decision-making process and (2) review a sample of plant assessments conducted between 1998 and 2000 to determine if any identified plant safety issues have not been adequately assessed. NRC has not yet taken action on these recommendations.

Some recommendations will require substantial resources to develop and implement. As a result, some implementation dates have slipped and some plans in response to the recommendations have changed in scope. For example, owing to resource constraints, NRC has postponed indefinitely the evaluation of methods to analyze the risk associated with passive reactor components such as the vessel head. Also, in part due to resource constraints, NRC has reconceptualized its plan to review licensee actions in response to previous generic communications, such as bulletins and letters.

Staff resources will be strained because implementing the recommendations adds additional responsibilities or duties—that is, more inspections, training, and reviews of licensee reports. For example, NRC's revised inspection guidance for more thorough examinations of reactor vessel heads and nozzles, as well as new requirements for NRC oversight of licensees' corrective action programs, will require at least an additional 200 hours of inspection per reactor per year. As of February 2004, NRC was also revising other inspection requirements that are likely to place additional demands on inspectors' time. Thus, to respond to these increased demands, NRC will either need to add inspectors or reduce oversight of other licensee activities.

To its credit, in its 2004 budget plan, NRC increased the level of resources for some inspection activities. However, it is not certain that these increases will be maintained. The number of inspection hours has fallen by more than one-third between 1995 and 2001. In addition, NRC is aware that resident inspector vacancies are filled with staff having varying levels of experience—from the basic level that would be expected from a newly qualified inspector to the advanced level that is achieved after several years' experience. According to the latest available data, as of May 2003,

about 12 percent of sites had only one resident inspector; the remaining 88 percent had two inspectors of varying levels of experience. Because of this situation, NRC augments these inspection resources with regional inspectors and contractors to ensure that, at a minimum, its baseline inspection program can be implemented throughout the year. Because of surges in the demand for inspections, NRC in 2003 increased its use of contractors and temporarily pulled qualified inspectors from other jobs to help complete the baseline inspection program for every plant. According to NRC, it did not expect to require such measures in 2004.

Similarly, NRC may require additional staff to identify and evaluate plants' operating experiences and communicate the results to licensees, as the task force recommended. NRC has currently budgeted an increase of three full-time staff in fiscal year 2006 to implement a centralized system, or clearinghouse, for managing the operating experience program. However, according to an NRC official, questions remain about the level of resources needed to fully implement the task force recommendations. NRC's operating experience office, before it was disbanded in 1999, had about 33 staff whose primary responsibility was to collect, evaluate, and communicate activities associated with safety performance trends, as reflected in licensees' operating experiences, and participate in developing rulemakings. However, it is too early to know the effectiveness of this clearinghouse approach and the adequacy of resources in the other offices available for collecting and analyzing operating experience information. Neither the operating experience office before it was disbanded nor the other offices flagged boric acid corrosion, cracking, or leakage as problems warranting significantly greater oversight by NRC, licensees, or the nuclear power industry.

NRC Has Not Proposed Any Specific Actions to Correct Systemic Weaknesses in Oversight and Decision-Making Processes

NRC's Davis-Besse task force did not make any recommendations to address two systemic problems: evaluating licensees' commitment to safety and improving the agency's process for deciding on a shutdown.

NRC's Task Force Recommendations Did Not Address Licensee Safety Culture

NRC's task force identified numerous problems at Davis-Besse that indicated human performance and management failures and concluded that FirstEnergy did not foster an environment that was fully conducive to ensuring that plant safety issues received appropriate attention. Although

the task force report did not use the term safety culture, as evidence of FirstEnergy's safety culture problems, the task force pointed to

- an imbalance between production and safety, as evidenced by FirstEnergy's efforts to address symptoms (such as regular cleanup of boric acid deposits) rather than causes (finding the source of the leaks during refueling outages);
- a lack of management involvement in or oversight of work at Davis-Besse that was important for maintaining safety;
- a lack of a questioning attitude by senior FirstEnergy managers with regard to vessel head inspections and cleaning activities;
- ineffective and untimely corrective action;
- a long-standing acceptance of degraded equipment; and
- inadequate engineering rigor.

The task force concluded that NRC's implementation of guidance for inspecting and assessing a safety-conscious work environment and employee concerns programs failed to identify significant safety problems. Although the task force did not make any specific recommendations that NRC develop a means to assess licensees' safety culture, it did recommend changes to focus more effort on assessing programs to promote a safety-conscious work environment.

NRC has taken little direct action in response to this task force recommendation. However, to help enhance NRC's capability to assess licensee safety culture by indirect means, NRC modified the wording in, and revised its inspection procedure for, assessing licensees' ability to identify and resolve problems, such as malfunctioning plant equipment. These revisions included requiring inspectors to

- review all licensee reports on plant conditions,
- analyze trends in plant conditions to determine the existence of potentially significant safety issues, and
- expand the scope of their reviews to the prior 5 years in order to identify recurring issues.

This problem identification and resolution inspection procedure is intended to assess the end results of management's safety commitment rather than the commitment itself. However, by measuring only the end results, early signs of a deteriorating safety culture and declining management performance may not be readily visible and may be hard to interpret until clear violations of NRC's regulations occur. Furthermore, because NRC directs its inspections at problems that it recognizes as being more important to safety, NRC may overlook other problems until they develop into significant and immediate safety problems. Conditions at a plant can quickly degrade to the extent that they can compromise public health and safety.

The International Atomic Energy Agency and its member nations have developed guidance and procedures for assessing safety culture at nuclear power plants, and today several countries, such as Brazil, Canada, Finland, Sweden, and the United Kingdom, assess plant safety culture or licensees' own assessments of their safety culture.[41] In assessing safety culture, an advisory group to the agency suggests that regulatory agencies examine whether, for example, (1) employee workloads are not excessive, (2) staff training is sufficient, (3) responsibility for safety has been clearly assigned within the organization, (4) the corporation has clearly communicated its safety policy, and (5) managers sufficiently emphasize safety during plant meetings. One reason for assessing safety culture, according to the Canadian Nuclear Safety Commission, is because management and human performance aspects are among the leading causes of unplanned events at licensed nuclear facilities, particularly in light of pressures such as deregulation of the electricity market. Finland specifically requires that nuclear power plants maintain an advanced safety culture and its inspections target the importance that has been embedded in factors affecting safety, including management. NRC had begun considering methods for assessing organizational factors, including safety culture, but in 1998, NRC's commissioners decided that the agency should have a performance-based inspection program of overall plant performance and should infer licensee management performance and competency from the results of that program. They chose this approach instead of one of four other options:

[41]The International Atomic Energy Agency is an international organization affiliated with the United Nations that provides advice and assistance to its members on nuclear safety matters.

- conduct performance-based inspections in all areas of facility operation and design, but not infer or articulate conclusions regarding the performance of licensee management;
- assess the performance of licensee management through targeted operations-based inspections using specific inspection procedures, trained staff, and contractors to assess licensee management—a task that would require the development of inspection procedures and significant training—and to document inspection results;
- assess the performance of licensee management as part of the routine inspection program by specifically evaluating and documenting management performance attributes—a larger effort that would require the development of assessment tools to evaluate safety culture as well as additional resources; or
- assess the competency of licensee management by evaluating management competency attributes—an even larger effort that would require that implementation options and their impacts be assessed.

When adopting the proposal to infer licensee management performance from the results of its performance-based inspection program, NRC eliminated any resource expenditures specifically directed at developing a systematic method of inferring management performance and competency. NRC stated that it currently has a number of means to assess safety culture that provide indirect insights into licensee safety culture. These means include, for example, (1) insights from augmented inspection teams, (2) lessons-learned reviews, and (3) information obtained in the course of conducting inspections under the Reactor Oversight Process. However, insights from augmented inspection teams and lessons-learned reviews are reactionary and do not prevent problems such as those that occurred at Davis-Besse. Further, before the Davis-Besse incident, NRC assumed its oversight process would adequately identify problems with licensees' safety culture. However, NRC has no formalized process for collectively assessing information obtained in the course of its problem identification and resolution inspection to ensure that individual inspection results would identify poor management performance. NRC stated that its licensee assessments consider inputs such as inspection results and insights, correspondence to licensees related to inspection observations, input from resident inspectors, and the results of any special investigations. However, this information may not be sufficient to inform NRC of problems at a plant in advance of these problems becoming safety significant.

In part because of Davis-Besse, NRC's Advisory Committee on Reactor Safeguards[42] recommended that NRC again pursue the development of a methodology for assessing safety culture. It also asked NRC to consider expanding research to identify leading indicators of degradation in human performance and work to develop a consistent comprehensive methodology for quantifying human performance. During an October 2003 public meeting of the advisory committee's Human Performance Subcommittee, the subcommittee's members again reiterated the need for NRC to assess safety culture. Specifically, the members recognized that certain aspects of safety culture, such as beliefs, perceptions, and management philosophies, are ultimately the nuclear power industry's responsibility but stated that NRC should deal with patterns of behavior and human performance, as well as organizational structures and processes. At this meeting, NRC officials discussed potential safety culture indicators that NRC could use, including, among other things, how many times a problem recurs at a plant, timeliness in correcting problems, number of temporary modifications, and individual program and process error rates. Committee members recommended that NRC test various safety culture indicators to determine whether (1) such indicators should ultimately be incorporated into the Reactor Oversight Process and (2) a significance determination process could be developed for safety culture. As of March 2004, NRC had yet to respond to the advisory committee's recommendation.

Despite the lack of action to address safety culture issues, NRC's concern over FirstEnergy's safety culture at Davis-Besse was one of the last issues resolved before the agency approved Davis-Besse's restart. NRC undertook a series of inspections to examine Davis-Besse's safety culture and determine whether FirstEnergy had (1) correctly identified the underlying causes associated with its declining safety culture, (2) implemented appropriate actions to correct safety culture problems, and (3) developed a process for monitoring to ensure that actions taken were effective for resolving safety culture problems. In December 2003, NRC noted significant improvements in the safety culture at Davis-Besse, but expressed concern with the sustainability of Davis-Besse's performance in this area. For example, a survey of FirstEnergy and contract employees conducted by FirstEnergy in November 2003 indicated that about 17

[42]The Advisory Committee on Reactor Safeguards is an independent committee comprising nuclear experts that advises NRC on matters of licensing and safety-related issues, and provides technical advice to aid the NRC commissioners' decision-making process.

percent of employees believed that management cared more about cost and schedule than resolving safety and quality issues—again, production over safety.

NRC's Task Force Recommendations Did Not Address NRC's Decision-Making Process

NRC's task force also did not analyze NRC's process for deciding not to order a shutdown of the Davis-Besse plant. It noted that NRC's written rationale for accepting FirstEnergy's justification for continued plant operation had not yet been prepared and recommended that NRC change guidance requiring NRC to adequately document such decisions. It also made a recommendation to strengthen guidance for verifying information provided by licensees. According to an NRC official on the task force, the task force did not assess the decision-making process in detail because the task force was charged with determining why the degradation at Davis-Besse was not prevented and because NRC had coordinated with NRC's Office of the Inspector General, which was reviewing NRC's decision making.

NRC's Failure to Track the Resolution of Identified Problems May Allow the Problems to Recur

The NRC task force conducted a preliminary review of prior lessons-learned task force reports to determine whether they suggested any recurring or similar problems. As a result of this preliminary review, the task force recommended that a more detailed review be conducted to determine if actions that NRC took as a result of those reviews were effective. These previous task force reports included: Indian Point 2 in Buchanan, New York, in February 2000; Millstone in Waterford, Connecticut, in October 1993; and South Texas Project in Wadsworth, Texas, from 1988 to 1994.[43] NRC's more detailed review, as of May 2004, was still under way. We also reviewed these reports to determine whether they suggested any recurring problems and found that they highlighted broad areas of continuing programmatic weaknesses, as seen in the following examples:

- *Inspector training and information sharing.* All three of the other task forces also identified inspector training issues and problems with information collection and sharing. The Indian Point task force called

[43]NRC formed the Indian Point lessons-learned task force in response to a steam-generator-tube rupture that forced a reactor shutdown. NRC formed the Millstone lessons-learned task force because the plant operated outside its design standards while refueling. NRC formed the South Texas task force in response to concerns about the effectiveness of NRC's inspection program and the adequacy of the licensee's employee concerns program.

upon NRC to develop a process for promptly disseminating technical information to NRC inspectors so that they can review and apply the information in their inspection program.

- *Oversight of licensee corrective action programs.* Two of the three task forces also identified inadequate oversight of licensee corrective action programs. The South Texas task force recommended improving assessments of licensees' corrective action programs to ensure that NRC identifies broader licensee problems.
- *Better identification of problems.* Two of the three task force reports also noted the need for NRC to develop a better process for identifying problem plants, and one report noted the need for NRC inspectors to more aggressively question licensees' activities.

Over the past two decades, we have also reported on underlying causes similar to those that contributed, in part, to the incident at Davis-Besse. (See Related GAO Products.) For example, with respect to the safety culture at nuclear power plants, in 1986, 1995, and 1997, we reported on issues relevant to NRC assessing plant management so that significant problems could be detected and corrected before they led to incidents such as the one that later occurred at Davis-Besse. Regardless of our 1997 recommendation that NRC require that the assessment of management's competency and performance be a mandatory component of NRC's inspection process, NRC subsequently withdrew funding to accomplish this. In terms of inspections, in 1995 we reported that NRC, itself, had concluded that the agency was not effectively integrating information on previously identified and long-standing issues to determine if the issues indicated systemic weaknesses in plant operations. This report further noted that NRC was not using such information to focus future inspection activities. In 1997 and 2001, we reported on weaknesses in NRC's inspections of licensees' corrective action programs. Finally, with respect to learning from plants' operating experiences, in 1984 we noted that NRC needed to improve its methods for consolidating information so that it could evaluate safety trends and ensure that generic issues are resolved at individual plants. These recurring issues indicate that NRC's actions, in response to individual plant incidents and recommendations to improve oversight, are not always institutionalized.

NRC guidance requires that resolutions to action plans be described and documented, and while NRC is monitoring the status of actions taken in response to Davis-Besse task force recommendations and preparing

quarterly and semiannual reports on the status of actions taken, the Davis-Besse action plan does not specify how long NRC will monitor them. It also does not describe how long NRC will prepare quarterly and semiannual status reports, even though, according to NRC officials, these semiannual status reports will continue until all items are completed and the agency is required to issue a final summary report. The plan also does not specify what criteria the agency will use to determine when the actions in response to specific task force recommendations are completed. Furthermore, NRC's action plan does not require NRC to assess the long-term effectiveness of recommended actions, even though, according to NRC officials, some activities already have an effectiveness review included. As in the past and in response to prior lessons-learned task force reports and recommendations, NRC has no management control in place for assessing the long-term effectiveness of efforts resulting from the recommendations. NRC officials acknowledged the need for a management control, such as an agencywide tracking system, to ensure that actions taken in response to task force recommendations effectively resolve the underlying issue over the long term, but the officials have no plans to establish such a system.

Conclusions

It is unlikely, given the actions that NRC has taken to date, that extensive reactor vessel corrosion will occur any time soon at another domestic nuclear power plant. However, we do not yet have adequate assurances from NRC that many of the factors that contributed to the incident at Davis-Besse will be fully addressed. These factors include NRC's failure to keep abreast of safety significant issues by collecting information on operating experiences at plants, assessing their relative safety significance, and effectively communicating information within the agency to ensure that oversight is fully informed. The underlying causes of the Davis-Besse incident underscore the potential for another incident unrelated to boric acid corrosion or cracked control rod drive mechanism nozzles to occur. This potential is reinforced by the fact that both prior NRC lessons-learned task forces and we have found similar weaknesses in many of the same NRC programs that led to the Davis-Besse incident. NRC has not followed up on prior task force recommendations to assess whether the lessons learned were institutionalized. NRC's actions to implement the Davis-Besse lessons-learned task force recommendations, to be fully effective, will require an extensive effort on NRC's part to ensure that these are effectively incorporated into the agency's processes. However, NRC has not estimated the amount of resources necessary to carry out these recommendations, and we are concerned that resource limitations could constrain their effectiveness. For this reason, it is important for NRC to not

only monitor the implementation of Davis-Besse task force recommendations, but also determine their effectiveness, in the long term, and the impact that resource constraints may have on them. These actions are even more important because the nation's fleet of nuclear power plants is aging.

Because the Davis-Besse task force did not address NRC's unwillingness to directly assess licensee safety culture, we are concerned that NRC's oversight will continue to be reactive rather than proactive. NRC's oversight can result in NRC making a determination that a licensee's performance is good one day, yet the next day NRC discovers the performance to be unacceptably risky to public health and safety. Such a situation does not occur overnight: Long-standing action or inaction on the part of the licensee causes unacceptably risky and degraded conditions. NRC needs better information to preclude such conditions. Given the complexity of nuclear power plants, the number of physical structures, systems, and components, and the manner in which NRC inspectors must sample to assess whether licensees are complying with NRC requirements and license specifications, it is possible that NRC will not identify licensees that value production over safety. While we recognize the difficulty in assessing licensee safety culture, we believe it is sufficiently important to develop a means to do so.

Given the limited information NRC had at the time and that an accident did not occur during the delay in Davis-Besse's shutdown, we do not necessarily question the decision the agency made. However, we are concerned about NRC's process for making that decision. It used guidance intended to make decisions for another purpose, did not rigorously apply the guidance, established an unrealistically high standard of evidence to issue a shutdown order, relied on incomplete and faulty PRA analyses and licensee evidence, and did not document key decisions and data. It is extremely unusual for NRC to order a nuclear power plant to shut down. Given this fact, it is more imperative that NRC have guidance to use when technical specifications or requirements may be met, yet questions arise over whether sufficient safety is being maintained. This guidance does not need to be a risk-based approach, but rather a more structured risk-informed approach that is sufficiently flexible to ensure that the guidance is applicable under different circumstances. This is important because NRC annually makes about 1,500 licensing decisions relating to operating commercial nuclear power plants. While we recognize the challenges NRC will face in developing such guidance, the large number and wide variety of

decisions strongly highlight the need for NRC to ensure that its decision-making process and decisions are sound and defensible.

Recommendations for Executive Action

To ensure that NRC aggressively and comprehensively addresses the weaknesses that contributed to the Davis-Besse incident and could contribute to problems at nuclear power plants in the future, we are recommending that the NRC commissioners take the following five actions:

- Determine the resource implications of the task force's recommendations and reallocate the agency's resources, as appropriate, to better ensure that NRC effectively implements the recommendations.
- Develop a management control approach to track, on a long-term basis, implementation of the recommendations made by the Davis-Besse lessons-learned task force and future task forces. This approach, at a minimum, should assign accountability for implementing each recommendation and include information on the status of major actions, how each recommendation will be judged as completed, and how its effectiveness will be assessed. The approach should also provide for regular—quarterly or semiannual—reports to the NRC commissioners on the status of and obstacles to full implementation of the recommendations.
- Develop a methodology to assess licensees' safety culture that includes indicators of and inspection information on patterns of licensee performance, as well as on licensees' organization and processes. NRC should collect and analyze this data either during the course of the agency's routine inspection program or during separate targeted assessments, or during both routine and targeted inspections and assessments, to provide an early warning of deteriorating or declining performance and future safety problems.
- Develop specific guidance and a well-defined process for deciding on when to shut down a nuclear power plant. The guidance should clearly set out the process to be used, the safety-related factors to be considered, the weight that should be assigned to each factor, and the standards for judging the quality of the evidence considered.
- Improve NRC's use of probabilistic risk assessment estimates in decision making by (1) ensuring that the risk estimates, uncertainties,

and assumptions made in developing the estimates are fully defined, documented, and communicated to NRC decision makers; and (2) providing guidance to decision makers on how to consider the relative importance, validity, and reliability of quantitative risk estimates in conjunction with other qualitative safety-related factors.

Agency Comments and Our Evaluation

We provided a draft of this report to NRC for review and comment. We received written comments from the agency's Executive Director for Operations. In its written comments, NRC generally addressed only those findings and recommendations with which it disagreed. Although commenting that it agreed with many of the report's findings, NRC expressed an overall concern that the report does not appropriately characterize or provide a balanced perspective on NRC's actions surrounding the discovery of the Davis-Besse reactor vessel head condition or NRC's actions to incorporate the lessons learned from that experience into its processes. Specifically, NRC stated that the report does not acknowledge that NRC must rely heavily on its licensees to provide it with complete and accurate information, as required by its regulations. NRC also expressed concern about the report's characterization of its use of risk estimates—specifically the report's statement that NRC's estimate of risk exceeded the risk levels generally accepted by the agency. In addition, NRC disagreed with two of our recommendations: (1) to develop specific guidance and a well-defined process for deciding on when to shut down a plant and (2) to develop a methodology to assess licensees' safety culture.

With respect to NRC's overall concern, we believe that the report accurately captures NRC's performance. Our draft report, in discussing NRC's regulatory and oversight role and responsibilities, stated that according to NRC, the completeness and accuracy of the information provided by licensees is an important aspect of the agency's oversight. To respond further to NRC's concern, we added a statement to the effect that licensees are required under NRC's regulations to provide the agency with complete and accurate information. While we do not want to diminish the importance of this responsibility on the part of the licensees, we believe that NRC also has a responsibility, in designing its oversight program, to implement management controls, including inspection and enforcement, to ensure that it has accurate information on and is sufficiently aware of plant conditions. In this respect, it was NRC's decision to rely on the premise that the information provided by FirstEnergy was complete and accurate. As we point out in the report, the degradation of the vessel head at Davis-Besse occurred over several years. NRC knew about several indications that

problems were occurring at the plant, and the agency could have requested and obtained additional information about the vessel head condition.

We also believe that the report's characterization of NRC's use of risk estimates is accurate. The NRC risk estimate that we and our consultants found for the period leading up to the December 2001 decision on Davis-Besse's shutdown, including the risk estimate used by the staff during key briefings of NRC management, indicated that the estimate for core damage frequency was $5.4x10^{-5}$, as used in the report. The $5x10^{-6}$ referenced in NRC's December 2002 safety evaluation is for core damage probability, which equates to a core damage frequency of approximately $5x10^{-5}$—a level that is in excess of the level generally accepted by the agency. The impression of our consultants is that some confusion about the differences in these terms may exist among NRC staff.

Concerning NRC's disagreement with our recommendation to develop specific guidance for making plant shutdown decisions, NRC stated that its regulations, guidance, and processes are robust and do provide sufficient guidance in the vast majority of situations. The agency added that from time to time a unique situation may present itself wherein sufficient information may not exist or the information available may not be sufficiently clear to apply existing rules and regulations definitively. According to NRC, in these unique instances, the agency's most senior managers, after consultation with staff experts and given all of the information available at the time, decide whether to require a plant shutdown. While we agree that NRC has an array of guidance for making decisions, we continue to believe that NRC needs specific guidance and a well-defined process for deciding when to shut down a plant. As discussed in our report, the agency used its guidance for approving license change requests to make the decision on when to shut down Davis-Besse. Although NRC's array of guidance provides flexibility, we do not believe that it provides the structure, direction, and accountability needed for important decisions such as the one on Davis-Besse's shutdown.

In disagreeing with our recommendation concerning the need for a methodology to assess licensees' safety culture, NRC said that the Commission, to date, has specifically decided not to conduct direct evaluations or inspections of safety culture as a routine part of assessing licensee performance due to the subjective nature of such evaluations. According to NRC, as regulators, agency officials are not charged with managing licensees' facilities, and direct involvement with organizational structure and processes crosses over to a management function. We

understand NRC's position that it is not charged with managing licensees' facilities, and we are not suggesting that NRC should prescribe or regulate the licensees' organizational structure or processes. Our recommendation is aimed at NRC monitoring trends in licensees' safety culture as an early warning of declining performance and safety problems. Such early warnings can help preclude NRC from assessing a licensee as being a good performer one day, and the next day being faced with a situation that it considers a potentially significant safety risk. As discussed in the report, considerable guidance is available on safety culture assessment, and other countries have established safety culture programs.

NRC's written response also contained technical comments, which we have incorporated into the report, as appropriate. (NRC's comments and our responses are presented in app. IV.)

As arranged with your staff, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from its issue date. At that time, we plan to provide copies of this report to the appropriate congressional committees; the Chairman, NRC; the Director, Office of Management and Budget; and other interested parties. We will also make copies available to others upon request. In addition, this report will be available at no charge on the GAO Web site at http://www.gao.gov. If you or your staff have any questions, please call me at (202) 512-3841. Key contributors to this report are listed in appendix V.

Jim Wells

Jim Wells
Director, Natural Resources
and Environment

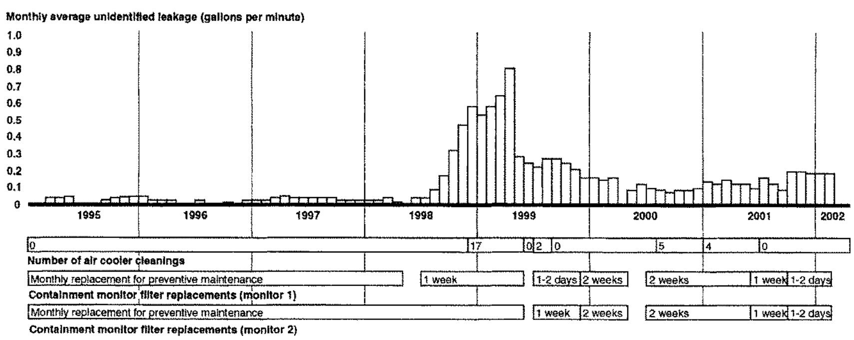
List of Congressional Requesters

The Honorable George V. Voinovich
United States Senate

The Honorable Dennis J. Kucinich
House of Representatives

The Honorable Steven C. LaTourette
House of Representatives

Time Line Relating Significant Events of Interest



Source: GAO analysis of FirstEnergy, Electric Power Research Institute, and Dominion Engineering data.

Analysis of the Nuclear Regulatory Commission's Probabilistic Risk Assessment for Davis-Besse

Report of the Committee to Review the NRC's Oversight of the Davis-Besse Nuclear Power Station

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Report of the Committee to Review the NRC's Oversight of the Davis-Besse Nuclear Power Station

1. Scope of the Review

The U. S. General Accounting Office formed a committee in September-October 2003 to review the oversight that the U. S. Nuclear Regulatory Commission provided on matters related to the pressure vessel head corrosion at the Davis-Besse (DB) Nuclear Power Station. The GAO charge to the committee was to respond to the questions:

(1) What probabilistic risk assessment model did NRC use and is it an appropriate model?
(2) What was the source of key data used to run NRC's probabilistic risk assessment and were these data valid?
(3) What key assumptions implicit in the model did NRC use to govern the estimated risk of different scenarios and were these reasonable?
(4) Is probabilistic risk assessment an appropriate tool for making such decision in these instances?
(5) How could NRC improve its use of probabilistic risk assessment to make more informed decisions?

The committee was initially provided with a set of 53 documents, which included GAO's preliminary analysis of the issues involved and chronology of the DB events during 2001 and 2002. The GAO reports summarized NRC-DB interactions in fall 2001 related to NRC Bulletin 2001-01 on control rod drive mechanism (CRDM) nozzle cracking, the eventual shutdown of the plant on 16 February 2002, and the subsequent discovery of pressure vessel head corrosion. Included also were:

(1) Official NRC documents, Generic Letters, Bulletins, and Information Notices transmitted to licensees including Davis-Besse,
(2) DB reports submitted to NRC related to the CRDM nozzle issues,
(3) NRC documents summarizing the staff's positions and discussions,
(4) Summaries of NRC staff presentations to NRC's Advisory Committee on Reactor Safeguards (ACRS) and to the Commission Technical Assistants,
(5) Event inquiry report of the NRC Office of Inspector General (OIG) and response from the NRC Chair,
(6) Redacted transcripts of OIG interviews of NRC staff, and
(7) Transcripts of GAO interviews with NRC staff.

The committee reviewed the initial set of documents received from GAO and conducted discussion on the phone and quite frequently via email. One member (GSW) provided a set of initial questions, which GAO used in a meeting with the NRC staff in October 2003. Another member (JCL) met with Mark Reinhart of NRC at the November American Nuclear Society meeting to discuss relevant technical issues and to prepare for a meeting of the review committee with NRC staff, which took place on December 11, 2003. At the meeting, two members (GSW, JCL) discussed technical and management issues with a total of nine NRC officials.

The review committee also consulted a number of experts from the industry and national laboratories, and reviewed a number of additional materials including:

(1) Several NRC Regulatory Guides,
(2) NRC Augmented Inspection Report and Lessons-Learned Task Force Report,

(3) Additional NRC reports on significance assessment of the DB CRDM degradations and the October 2003 OIG review of NRC's oversight on DB,
(4) Reports (including one proprietary version) from Electric Power Research Institute and Nuclear Energy Institute,
(5) Notes from William Shack, Argonne National Laboratory (ANL), describing his calculation of CRDM nozzle failure probability,
(6) DB probabilistic risk assessment (PRA) study performed for NRC by the Idaho National Engineering and Environmental Laboratory,
(7) Transcripts of several ACRS meetings during 2001–2003, and
(8) Select papers in engineering journals and proceedings.

The committee conducted an extensive review and discussion on the probabilistic risk calculations performed both by the FirstEnergy Nuclear Operating Company (FENOC) and NRC for Davis-Besse. One committee member (JCL) also developed a simplified analytical model to determine the CRDM failure probability, which provided a rough check on numerical calculations performed at ANL.

Following the 11 December 2003 meeting with the NRC staff, the committee made an effort to follow up on a number of questions that required additional information or clarifications. One essential piece of information is the core damage probability due to the postulated CRDM failure and ejection that NRC actually used in connection with the decision to allow continued DB operation until February 16, 2002. After a long wait, finally on February 24, 2004, the committee received a response from Jin Chung, Richard Barrett, and Gary Holahan, summarizing, to the extent they could reconstruct, how NRC arrived at key quantitative risk estimates in November 2001.

We present in Section 2 key findings of the committee on NRC's oversight related to the DB issues. We provide responses to the first four GAO charges in Sections 3 through 6, in a slightly restructured format, covering (a) PRA methodology and data used in NRC's risk assessment, (b) assumptions and uncertainties in the risk assessment, (c) relevant regulations and guidelines, and (d) November 2001 NRC decision. Our response to the fifth GAO charge is finally presented in Section 7.

2. Key Findings of the Committee

The committee presents key findings of its review on NRC's oversight on Davis-Besse and related safety and regulatory issues:

(1) NRC's Risk Analysis for Davis-Besse

(a) To guide a risk-informed decision on whether to grant an extension beyond its December 31, 2001 date for shutdown of Davis-Besse for nozzle inspection, NRC relied on its PRA of risks from crack-induced failure of control-rod housing nozzles. The calculated risk was incorrectly small because the calculations did not consider corrosion of the reactor vessel due to boric acid in coolant leaking through the cracks. The calculated risk was also subject to large uncertainties. As a result, NRC staff found it difficult to balance results of quantitative risk calculations against qualitative considerations. Regulatory Guide 1.174 provided little help in this regard.

(b) NRC did not perform uncertainty analysis in applying PRA in the DB decision-making process and there was confusion regarding the interpretation of core damage frequency (CDF) and core damage probability (CDP) as risk attributes within the framework of RG 1.174. NRC staff should have recognized large uncertainties associated with the CDF estimated for CRDM nozzle failures

(c) NRC's risk analysis was poorly documented and inadequately understood by NRC staff.

(d) Even now, NRC is unable to provide estimates of the risk from continued operation of Davis-Besse from December 31, 2001 to February 16, 2002, taking into account the large corrosion cavity in the reactor vessel head found in March 2002. The risks from that operation prior to shutdown are likely to have been unacceptably large. Thus, with proper risk analysis, quantified risk calculations would have provided clear guidance for prompt shutdown.

(2) Relevant Regulations and Guidelines

(a) Coolant leakage through flanges and valves was allowed under the DB Technical Specifications, leading the DB personnel and NRC resident inspectors to treat boric acid deposits in various locations in the containment as routine events, and hence not risk significant.

(b) NRC has no predetermined methodology to weigh PRA against deterministic factors. NRC needs to develop a set of guidelines for the use of PRA in decision-making.

(3) November 2001 Davis-Besse Decision

(a) The proposed shutdown date of 31 December 2001 was arbitrary. There was significant pressure from DB to delay the shutdown for financial reasons, but no cost-benefit analysis was presented.

(b) Communication was seriously lacking between NRC headquarters and Region III and also between resident inspectors and Region III administrators regarding the extent of coolant leakage and boric-acid corrosion.

(c) NRC staff incorrectly assumed that the visible white deposits of anhydrous boric acid resulted entirely from rapid evaporation and drying of the leaking coolant and were not associated with corrosion.

(d) The transparency of the decision-making process within NRC is not uniform. The NRC lacks an established and well-defined process for decision-making.

(4) General Safety and Regulatory Issues

(a) How to ensure safety from corrosion by leaking coolant is generic to all pressurized water reactors (PWRs). There is no evidence that it has been evaluated as such by NRC's Advisory Committee on Reactor Safeguards.

(b) The root cause of this near miss of a serious accident at Davis-Besse is human error: inadequate evaluation of the effect of simplifying assumptions in the risk analysis and inadequate perception and understanding of the many clues that challenged those assumptions.

(c) NRC is slow to integrate new safety information into its programs, and to share that information with its licensees.

3. NRC Probabilistic Risk Assessment Model and Database

3.1 Basic PRA Methodology and Data Used for the DB Risk Analysis

The NRC staff relied on a Standardized Plant Analysis Risk (SPAR) study [Sat00] for Davis-Besse that Idaho National Engineering and Environmental Laboratory performed. The Saphire code [Sap98] provided the PRA tools and database for key system failure rates and human error probabilities in the SPAR study. The PRA methodology combines semi-pictorial structures of event and fault trees to estimate the probability of occurrence of rare events, in particular, the core damage frequency (CDF) and large early release frequency (LERF) of radioactivity associated with the operation of a nuclear power plant. An event tree is constructed for each major sequence of events beginning with an initiating event, e.g., a medium-break loss-of-coolant accident (MBLOCA), and following through multiple stages of safety systems to be activated. The probability of failure or unreliability of a safety system that is called upon to function is determined as the probability of the top event of a fault tree, which is determined through Boolean logic representing failure probabilities of components making up the top event. Uncertainties in the CDF and LERF are then obtained by a Monte Carlo convolution of probability density functions representing failure rates of components in fault trees and of safety systems in event trees.

The MBLOCA, which is assumed to occur following the failure and ejection of CRDM nozzles at Davis-Besse, is analyzed in the SPAR report [Sat00] as one of 12 major internal events postulated to lead to core damage and radioactivity release. A baseline CDF of 1.0×10^{-7}/year for MBLOCA results from a generic value [Pol99] of the initiating event frequency of 4.0×10^{-5}/year for the MBLOCA combined with the failure probabilities of a number of engineered safety features, including high- and low-pressure injection systems. This results in an estimate of 2.5×10^{-3} for the conditional core damage probability (CCDP) for MBLOCA. The CCDP of 2.5×10^{-3} is almost entirely due to the failure of low-pressure recirculation pumps, which in turn depends heavily on the ability of the operator to properly align and start the pumps. Based on human factor analysis, an estimate of 1.0×10^{-3} for the operator error is included in determining the CCDP of 2.5×10^{-3}. The baseline or point-estimate CDF of 1.0×10^{-7}/year for MBLOCA contributes 0.5% toward the total baseline CDF of 2.0×10^{-5}/year, with uncertainties represented as CDF = {5th percentile, median, mean, 95th percentile | 6.3×10^{-6}, 1.6×10^{-5}, 5.1×10^{-5}, 9.6×10^{-5}} per year. The SPAR report for Davis-Besse provides only baseline CDF estimates for individual core damage events; hence no uncertainty estimates are available for the MBLOCA event. The mean overall CDF = 5.1×10^{-5}/year for Davis-Besse compares well with the those for internal initiating events for three PWR plants analyzed extensively as part of NRC's severe accident evaluation project in NUREG-1150 [Nrc90]: Surry Unit 1, 4×10^{-5}/year; Sequoyah Unit 1, 6×10^{-5}/year; and Zion Unit 1, 6×10^{-5}/year. The CDF estimates for the four PWRs are, however, an order of magnitude larger than those for two boiling water reactors analyzed in NUREG-1150: Peach Bottom Unit 2, 5×10^{-6}/year, and Grand Gulf Unit 1, 4×10^{-6}/year.

3.2 DB Calculation of Risk due to CRDM Nozzle Failures

The DB calculation of the nozzle failure probability consisted of the following steps [Cam01c]. The nozzles were divided into three groups based on the extent of visual inspection possible during refueling outage (RFO) 10, 11 and 12. Group 1 consisted of 15 nozzles that were not inspected during RFO 10 and 11. Group 2 consisted of 5 additional nozzles that were not inspected during RFO 12. Group 3 consisted of 45 nozzles, all of which were inspected during all outages. This analysis accounts for 65 nozzles, four short of the total number of nozzles on the DB head. The four nozzles not

included in this analysis are at the center of the head. They were determined by a Structural Integrity Associates analysis [Cam01d] to have no demonstrable annular gaps, and therefore, were considered as not susceptible to circumferential cracking and were excluded from the calculation. This particular assumption turned out to be quite inappropriate, since the February-March 2002 inspection revealed that three central nozzles (Nos. 1, 2, 3) had developed through-wall axial cracks and that nozzle 2 also had a circumferential crack.

Leak frequencies were determined for each group according to the equation: leak frequency = 1.1/year × F_i, where F_i is the fraction of the total nozzles (65) in group i, and the value of 1.1 is the estimated frequency of CRDM leaks per reactor year based on observations on 5 other Babcock and Wilcox (B&W) plants. Data on CRDM cracking noted in the 2001-01 NRC Bulletin were incorporated into the PRA analysis [Cam01c] in calculating the leak frequency. Specifically, recent inspections had revealed that there were sixteen leaking nozzles identified in the B&W plants, Arkansas Nuclear One Unit 1 (ANO-1), Crystal River Unit 3 (CR-3), Oconee Nuclear Station Unit 1 (ONS-1), ONS-2 and ONS-3. The assumption was made that all leaks appeared during the most recent two fuel cycles. Assuming 1.5 years per fuel cycle, 2 cycles per plant and 5 plants, a product of these three values yields 15 reactor years of operation. Sixteen leaking nozzles over 15 years of operation yields a leak frequency of about 1.1 leaks per reactor year. This value then incorporated the most recent data on CRDM cracking at other B&W plants.

An event tree was constructed for each CRDM group, beginning with the CRDM leak frequency, accounting for crack growths and failures during subsequent operation and CRDM nozzle inspection failures, and culminating with a total CDF. The event tree analysis included CCDP = 2.7×10^{-3} for all groups. The resulting total CDF summed over all three groups was 6.97×10^{-6}/year. Dividing by the CCDP yielded a value of the initiating event (IE) frequency of 2.58×10^{-3}/year representing an MBLOCA due to CRDM nozzle ejection. Using the IE frequency, one would then calculate an IE probability of 3.4×10^{-4} for continued DB operation for another 0.13 year, representing the period between 31 December 2001 and 16 February 2002. We note here also that the DB estimation of CCDP = 2.7×10^{-3} agrees closely with the SPAR estimate of 2.5×10^{-3} discussed in Section 3.1.

The probability of missing a leak in an inspection was estimated by Framatome [Cam01b] using human reliability analysis. Their estimates [Cam01d] indicated that the probability of missing a leak was 0.06 in the first inspection (RFO 10), 0.065 in the second inspection (RFO 11) and 0.11 in subsequent inspections. Davis-Besse's analysis [Cam01c], however, uses a single probability of value 0.05 applied to all of the nozzles covered in RFO 10, 11 and in subsequent inspections. The document [Cam01c] references the Framatome analysis [cam01b], but does not indicate why a different value was used and why a single, lower value was applied for all inspections. Correcting, however, the calculation to account for the three separate failure detection probabilities results in an IE frequency of 2.64×10^{-3}/year vs. 2.58×10^{-3}/year assumed [Cam01c].

3.3 NRC Calculation of Risk due to CRDM Nozzle Failures

Although documents provided to the review committee do not provide sufficient details on how NRC arrived at the incremental CDF or core damage probability (CDP), it appears that the NRC staff used the DB estimate of CCDP = 2.7×10^{-3} for the MBLOCA initiated by CRDM nozzle failure and ejection. The NRC did not have the in-house expertise to determine the nozzle ejection probability for Davis-Bessie. They had two sources for estimates of the nozzle ejection probability. One source was Dr. William Shack at Argonne National Laboratory (ANL). Dr. Shack conducted a rather extensive

analysis of the failure probability consisting of 5 steps: 1) the number of cracked nozzles, 2) the crack size distribution, 3) the crack growth rate, 4) a time to failure based on initial crack size and crack growth rate, and 5) a probability of failure, based on a Monte Carlo analysis of failure times. The end result was a plot and a table with failure probability vs. time that was provided to NRC and is described in several references [Sha01, Sha03, Nrc01a]. The second source of information on the MBLOCA frequency was the DB estimate [Cam01c] for IE frequency of 2.58×10^{-3}/year, discussed in Section 3.2.

Documents provided to the review committee [Rei03, Chu04] list the IE probability of 2.0×10^{-3} for continued operation for another 0.13 year, representing the period between 31 December 2001 and 16 February 2002, but reference Dr. Shack as the source. However, the values provided by Shack to the NRC [Sha01] do not agree with this number and apparently NRC decided not to use the ANL analysis, as it was viewed as preliminary, and a work in progress.

In a final response [Chu04] to questions the review committee raised following the 11 December 2003 meeting with nine NRC staff, Jin Chung, Richard Barrett, and Gary Holahan confirmed that NRC used the DB estimate of CCDP = 2.7×10^{-3}, coupled with the IE frequency of 2.0×10^{-2}/year, to obtain an incremental CDF = 5.4×10^{-5}/year, associated with the postulated CRDM failure and ejection leading to an MBLOCA. They indicate that, instead of allowing for the inspection failure probability of 0.05 for RFO 10, assumed in the Framatome risk calculation [Cam01c], NRC allowed no credit to discover the nozzle cracking. NRC, however, used the same crack growth and failure rates as in the Framatome PRA submittal to arrive at the IE frequency of 3.4×10^{-2}/year, which is an order of magnitude larger than the Framatome estimate of 2.58×10^{-3}/year. Dr. Chung then decided to reduce the IE frequency to 2.0×10^{-2}/year to "reflect best estimate rather than 75 percentile fracture mechanics," which is the best description of the adjustment that NRC is able to present in February 2004. The adjusted value of IE frequency = 2.0×10^{-2}/year is then used together with CCDP = 2.7×10^{-3} to yield the incremental CDF = 5.4×10^{-5}/year. Finally, to convert the incremental CDF to an incremental CDP, associated with the continued DB operation for 0.13 year, NRC again rounded off the resulting CDP = 7.0×10^{-6} to 5.0×10^{-6}. In the deliberations leading to the 28 November 2001 DB decision, NRC apparently used the adjusted, rounded-off risk estimates: incremental CDF = 5.4×10^{-5}/year and incremental CDP = 5.0×10^{-6}.

The conclusion of the review committee is that the determination of IE probability is questionable, and that the error or uncertainty associated with this probability is likely to be very high, rendering it of questionable value. In the February 2004 response [Chu04] to the review committee questions, NRC confirms that no uncertainty analysis was performed on the incremental CDF and CDP estimates they used in November 2001. Furthermore, NRC proposes an unusual use of the incremental CDF and CDP values to compare with the quantitative guidelines given in RG 1.174 [Nrc02a]. This will be discussed further in Section 5.1.

4. Assumptions and Uncertainties in NRC Risk Analysis

4.1 The Discovery of Massive Corrosion Wastage at Davis-Besse

The most serious shortcoming in NRC's risk analysis was the complete neglect of any consideration of corrosion of the reactor vessel by boric acid in reactor coolant known to be leaking from the high-pressure cooling system. After finally shutting down the reactor and inspecting the control housing nozzles, Davis-Besse discovered extensive corrosive wastage of the steel pressure vessel. Boric acid in leaking coolant had reacted with iron to form a mass of corrosion products which, when removed, left a cavity the size of a

pineapple. Corrosion had penetrated the 6-inch thick steel head of the reactor vessel and exposed the thin corrosion-resistant vessel liner, found to be only about 0.2 inches thick at that location.

The reactor had been operating for months, maybe years, perilously close to rupture of the vessel liner and rapid loss of reactor coolant. In response to our repeated requests to NRC to share with us what it has learned about the risks from corrosion-induced failure of the coolant pressure boundary, NRC states that such analysis has not been completed, awaiting completion of laboratory tests on relevant failure mechanics at the Oak Ridge National Laboratory. That answer is most disappointing.

An earmark of a responsive safety program is prompt incorporation of new safety information, by undertaking new risk analysis, whether deterministic, probabilistic, or both, to guide new procedures that would avoid such a potential accident and to guide research and testing necessary for proper risk-informed decision making. Now, some two years since the discovery of massive and dangerous corrosion wastage at Davis-Besse, NRC seems unable to supply even preliminary analysis of the magnitude of potential safety problems arising from coolant leakage and corrosion. This harks back to the 1977-79 era, when NRC failed to recognize the implications of a near miss of a serious reactor accident at Davis-Besse, discussed further in Section 6.6. If NRC had made a prompt analysis of Davis-Besse's 1977 operator errors and the implications for a more serious accident if not corrected, and if that analysis had been communicated to other licensees, the tragic accident at Three Mile Island could have been avoided. It appears that NRC has not fully recovered from its mistakes in 1977-79.

4.2 Assumption that Boric Acid in Hot Escaping Coolant Will Not Corrode

Apparently all NRC staff who were involved in the November 2001 decision on Davis-Besse were aware that high-pressure coolant was leaking from valves, flanges, and possibly from cracks, but they evidently thought that the hot coolant, at 600 °F, would immediately flash into steam and non-corrosive anhydrous compounds of boric acid. As evidence, they referred to the readily visible deposits of white fluffy anhydrous boric acid observed on plant equipment. But evaporation concentrates boric acid in the remaining liquid, which becomes far more corrosive. Its vapor pressure decreases and slows further evaporation. Thus, one should expect that some of the boric acid in the escaping coolant can reach the metal surfaces as wet or moist highly corrosive material underlying the white fluffy surface layers. That is evidently what happened. It should have been anticipated.

Also the geometry of a cracked nozzle was not considered in NRC's thoughts about boric acid corrosion. NRC was focused on the metal surface because they were convinced that the boric acid they saw came from "dripping" from the leaky valves above the head. However, in a leaking nozzle, the escape path of the water is some 6-8 inches – from the clad to the vessel surface. Such a long crevice provides considerably greater opportunity for concentration of the liquid behind the evaporation front at or near the vessel head surface where the steam escapes.

NRC staff should also have been aware of experience at the French nuclear plants, where boric acid corrosion from leaking reactor coolant had been identified during the previous decade, the safety significance had been recognized, and safety procedures to mitigate the problem had been implemented. Keeping abreast of safety issues at similar plants, whether domestic or abroad, and conveying relevant safety information to its licensees is an important function of NRC's safety program.

NRC staff were involved a few years earlier in discussions regarding boric acid deposits on the reactor pressure vessel head [Epr01]. Boric-acid corrosion programs were initiated. But to the NRC staff involved in the November 2001 decision on Davis-Besse, boric-acid corrosion was not viewed as a significant safety concern; rather, there was concern that the anhydrous crystals could obscure indication of leakage from the nozzles above the reactor head. But already several tests of boric acid corrosion had been underway in industry and government laboratories. Representative tests of nozzle leakage showed that corrosion rates from boric acid solutions dripping onto carbon steel at 600 °F can be in the range of four inches per year [Nrc02b]. Drip tests sponsored by the Electric Power Research Institute [Sri98, Epr01] showed that the corrosion rate is much higher for carbon-steel surfaces at 600 °F than at lower temperature. Only at temperatures much higher than 600 °F is the vaporization rate high enough to produce anhydrous boric acid crystals with little corrosion.

NRC personnel involved in the November 2001 safety review evidently were not aware of these corrosion tests or else they had forgotten about them. An NRC resident inspector at Davis-Besse was shown, by a Davis-Besse engineer, a photograph that revealed streaks of rust-colored corrosion products on the head of the reactor vessel, in the midst of the expected white crystals. But the inspector was not aware of the significance of these rust streaks, and he did not report this information to other NRC personnel. At other times, Davis-Besse reported the presence of airborne rust particles that had lodged on the surveillance filters, but the significance of this information was not recognized.

After the discovery of the corrosion wastage in 2002, an NRC official was asked about the corrosion data reported by the Electric Power Research Institute (EPRI). He replied that those data were not considered in the discussions with Davis-Besse because EPRI had not "submitted" the report of those data to NRC. EPRI points out that the corrosion data had been published in 1998 in a widely available technical report, well known to industry and NRC. EPRI had not formally "submitted" the report because NRC charges a fee for the submittal process.

4.3 Control Rod Ejection and Reactivity Transient

In discussions related to the consequences of CRDM nozzle ejections at Davis-Besse, NRC duly considered the effects of the control rods ejected, thereby made inoperable, in the resulting LOCA. They apparently concluded before the 28 November 2001 Davis-Besse decision that the negative reactivity feedback resulting from the overheating and boiling of coolant in a LOCA would easily overshadow any potential decrease in the amount of subcritical reactivity that would ensure safe shutdown of the reactor. Furthermore, a more recent NRC report [Dye03] evaluating the significance of the Davis-Besse CRDM penetration cracking and pressure vessel head degradation presents a similar conclusion. Here, a combined thermal-hydraulic and reactivity transient analysis performed with the RELAP code indicates that the boiling of the reactor coolant coupled with the addition of boric acid in the emergency coolant water injected is sufficient to maintain the shutdown condition, thereby obviating the concern for an anticipated transient without scram (ATWS).

One consequence of the CRDM nozzle ejection that has not been, however, analyzed is the positive reactivity inserted into the reactor core when the control rod ejection occurs in a hot zero power (HZP) rather than a hot full power (HFP) condition. The consequences of postulated control rod ejection accidents are generally more severe, if initiated in a HZP condition when the system is fully pressurized but at low power. This is because at HZP the control rods would be inserted deeply into the core, thereby adding

a larger positive reactivity when the rods are ejected, than that resulting in a HFP rod ejection accident. Thus, a HZP CRDM nozzle ejection could result in a power level above rated power before a significant coolant heating or boiling occurs. This combination of postulated accidents requires an integrated analysis of two PWR design basis accidents, LOCA and rod ejection accident, and should be performed for a complete evaluation of CRDM nozzle ejection consequences.

4.4 Need to Account for Corrosion in Risk Analysis

NRC's analysis of risks from nozzle cracking was concerned only with the formation and propagation of circumferential cracks that could result in nozzle failure, loss of coolant, and even control rod ejection. The formation of axial cracks was neglected in the risk analysis. There is less chance of axial cracks causing complete failure of a nozzle but they do open additional pathways for coolant leakage. Leakage from axial cracks is believed to have been the main source for the massive corrosion wastage at Davis-Besse.

Neglecting axial cracking and corrosion wastage that could result in rupture of the reactor vessel and a more serious loss-of-coolant accident was a principal deficiency in NRC's risk assessment.

NRC has not described to us any plans for extensions to its risk analysis that would predict the dangers of corrosion wastage. In our view, the necessary additional ingredients of the probabilistic risk analysis must include:

- Formation and growth of axial cracks in control-rod-housing nozzles,
- Flow of leaking coolant from cracks,
- Evaporation of leaking coolant and concentration of boric acid,
- Corrosion of the steel pressure vessel,
- Time-dependent penetration of the corrosion front into the pressure vessel,
- Corrosion and stress-corrosion cracking of the vessel liner,
- Time-dependent calculation of stress on the vessel and its failure if ruptured, and
- Loss-of-coolant analysis of reactor core damage if rupture occurs.

Some of the possible parameters for such an analysis were developed for this report from sources other than NRC, as outlined in the next section. The wide variations in some of the key parameters illustrate uncertainties that must be resolved to make accurate predictions of risk and its uncertainty.

4.5 Uncertainties in Predicting Risks from Nozzle Cracking

For risk-informed decision making, it is important to include calculation of uncertainties in the predicted risks. NRC informs us that it has not calculated uncertainties in its present risk assessments of nozzle cracking. It does believe that its present results on core-damage risks are accurate "to within a factor of 2 or 3". NRC did not provide the basis for their belief. The information necessary for probabilistic risk calculation should include enough data for uncertainty analysis. NRC should perform uncertainty calculations.

A major uncertainty arises in attempting to predict the corrosion wastage that would rupture the reactor vessel, particularly after boric-acid-induced corrosion has penetrated all the way through the carbon steel and exposed the thin stainless steel liner that would serve as the reactor coolant system pressure boundary, as occurred at Davis-Besse. From other sources [Pin03a,b], we are informed that in early 2003 an internal NRC memo concluded that there was no danger of imminent rupture of the Davis-Besse reactor prior

to its shutdown in February 2002. The memo cited calculations by the Oak Ridge National Laboratory that the as-discovered cavity could have supported twice the operating pressure of 2185 psia before rupturing and that, "had the cavity enlarged under continued operation, at least twelve months remained before the cavity would reach a size that rupture would occur at normal operating temperature and pressure." It was assumed that "the wastage cavity was actively growing at a maximum rate of seven inches per year" [Pin03a], much greater than the 4 inches per year quoted earlier by NRC. The NRC memo stated that the need for more accurate data on the morphology and depth of cladding cracks necessitates a revision of these calculations and expects a possible reduction in the amount of margin that was originally calculated.

A report by Structural Integrity Associates [Sia02], commissioned by FirstEnergy, calculated that the cladding could withstand pressures of more than 5000 psia. Davis-Besse concluded that vessel rupture "was therefore considered not to be a credible event". Later in 2003, an Oak Ridge National Laboratory study, conducted on a spare reactor-vessel head with a machined-out cavity simulating wastage, reported two rupture tests, one occurring at 2000 psia, the other at 2700 psia. If these two results are applicable, Davis-Besse had been operating at 2185 psia with significant probability of vessel rupture. NRC's project manager for these tests stated in October 2003 that the Oak Ridge test results would be made public "probably within weeks." The report is not yet released.

An important feature of the Oak Ridge tests was taking into account the "dissimilar weld" between the carbon-steel vessel head and the stainless steel cladding. The Union of Concerned Scientists pointed out that the Oak Ridge tests revealed that the weld overlay process used for the Davis-Besse vessel left a thin interface that was not as strong as either of the adjoining layers. Also, the tests were conducted quasi-statically, whereas pressure transients during reactor operation must be considered [Pin03b].

These are examples of crucial data uncertainties that need to be resolved. Such uncertainties must be considered in reporting probabilistic risks.

It is not enough to finesse such uncertainties by instituting new procedures intended to eliminate the possibility of operator error. The near accident at Davis-Besse resulted from human error, errors by reactor operators, by NRC on-site inspectors and by the staffs at Davis-Besse and NRC. The experience at Three Mile Island has taught us that human errors can occur and must be included in responsible risk analysis.

4.6 Lack of Uncertainty Analysis in DB Risk Estimation

As discussed in Section 4.5, an important issue regarding the application of quantitative guidelines for risk management and regulatory decisions, as in the Davis-Besse case under review, is the need to account for uncertainties in risk values determined through PRA techniques. It was noted in Sections 3.1 and 3.3 that we are unable to obtain any uncertainty estimates for the SPAR baseline CDF of 1.0×10^{-7}/year for Davis-Besse MBLOCA, without CRDM nozzle failures, or the NRC estimate of 5.4×10^{-5}/year for the corresponding MBLOCA CDF accounting for CRDM nozzle failures. It is well known among the PRA community that all quantitative risk estimates for nuclear power plants are subject to significant uncertainties and that it is imperative that proper uncertainty analysis be performed for any PRA study for nuclear power plants. This point was made abundantly clear in a recent NRC report [Fle03], prepared at the request of NRC's Advisory Committee on Reactor Safeguards (ACRS), for the purpose of evaluating practices and issues regarding PRA applications. The need to understand and characterize uncertainties in PRA and risk-informed regulatory activities was also

emphasized in both RG 1.174 [Nrc02a] and RG 1.200 [Nrc03]. Furthermore, it was primarily for the purpose of duly accounting for uncertainties in the calculated risks of postulated severe accidents that NRC and its contractors had to go through two draft versions of the massive volumes of the severe accidents risk study of NUREG-1150 [Nrc90] before releasing the final version in 1990. Nonetheless, it is rather clear to the review committee that the NRC staff and management did not give due considerations to the impact of large uncertainties, in particular, in the frequency of MBLOCA initiated by the postulated Davis-Besse CRDM nozzle ejection in their Davis-Besse deliberations in November 2001. In addition, the SPAR calculation of CCDP = 2.5×10^{-3} is subject to significant uncertainties associated with human errors and common cause failures represented in the fault tree analysis. Questions were also raised in GAO interviews with the NRC staff if the staff had the proper understanding of the impact on the CCDP estimate of the compensatory measures proposed by Davis-Besse before the November 2001 decision.

During the 11 December 2003 meeting with the NRC staff, we got the indication that several NRC staff felt that Regulatory Guide 1.174 [Nrc02a], with its PRA framework, does account for uncertainties in risk estimates including the effects of unknown events, e.g., the Davis-Besse pressure vessel head wastage, through the defense-in-depth philosophy. As discussed in detail in the February 2003 NRC Region III report [Dye03], it is very much doubtful how the system modeling uncertainties and unknown events could possibly have been represented through a simple application of RG 1.174. It is noteworthy that the ACRS, at its first full committee meeting [Acr02] after the Davis-Besse cavity findings, repeatedly criticized the NRC staff for not having performed any uncertainty analysis for the CRDM nozzle failure issues and suggested that the staff had drifted away from the RG 1.174 guidelines. Had the staff gone through even a simple analysis, without any detailed uncertainty calculations or invoking RG 1.174, they should have realized that the *incremental* CDF of 5.4×10^{-5}/year would result in doubling the total CDF for Davis-Besse, even with the mean SPAR value of 5.1×10^{-5}/year. Note furthermore that the SPAR baseline CDF is 1.6×10^{-5}/year. Thus, the staff should have readily recognized the risk significance of the incremental CDF = 5.4×10^{-5}/year estimated in November 2001 for the CRDM nozzle failure event.

One regulatory decision-making case where PRA applications were questioned is the ATWS issue. A recent review [Rau03] emphasizes that the uncertainty in the calculated values of the reactor scram system reliability requires maintaining defense in depth regarding ATWS, rather than relying heavily on PRA results. Thus, despite small values of scram failure probabilities calculated in the early 1980s, system changes, including improved reactor shutdown systems and circuits, were implemented but only after incipient ATWS events had occurred at the Salem Unit 1 plant in 1983 [Sci83]. We suggest that the NRC staff should have applied the lessons learned from the ATWS rulemaking case to the DB case, which would have reduced the NRC staff's heavy reliance on the quantitative risk. Although we will never be able to determine the extent by which the incremental CDF or CDP values influenced the decision making, it is rather apparent to the review committee that the quantitative risk values, without due considerations for uncertainties, did play an important role in the 28 November 2001 decision.

5. Relevant Regulations and Guidelines

5.1 Use of Regulatory Guide 1.174 and Other Guidelines in the DB Decision

One key set of guidelines discussed extensively among the NRC staff and management before the 28 November 2001 DB decision is RG 1.174 [Nrc02a], which is intended to

promote risk-informed decisions on plant-specific changes. Included in RG 1.174 is one particular quantitative metric in the form of incremental CDF. According to Figure 3 illustrating acceptance guidelines, any plant-specific changes resulting in an incremental CDF of 1×10^{-5}/year or higher should not be allowed. In addition, there apparently was considerable discussion and lack of unanimity among the NRC staff prior to the 28 November 2001 decision if the other four safety principles of RG 1.174 were satisfied. The February 2003 NRC Region III report [Dye03] documenting the significance of the Davis-Besse CRDM penetration cracking and pressure vessel head degradation leaves, however, no question that all five safety principles of REG 1.174 were violated at Davis-Besse in November 2001. Included in this report is a revised estimate of incremental MBLOCA frequency of 3.0×10^{-2}/year, yielding estimates of incremental CDF in the range of $[1\times10^{-5}, 1\times10^{-4}]$ per year, due to the ejection of three central CRDM nozzles. These estimates of incremental CDF bracket the value of 5.4×10^{-5}/year presented to the review committee [Rei03] and would have clearly resulted in violation of the sole quantitative metric of RG 1.174.

Although the February 2003 findings of NRC rendering Davis-Besse in the "red" status are attained certainly with the benefits of hindsight, it is worth summarizing the reasoning presented in the report, rather than presenting the review committee's evaluations:

(1) Principle 1: *Regulations were not met*, because reactor coolant system (RCS) pressure boundary leakage occurred over an extended period of time and the RCS was not inspected and maintained properly. This resulted in violation of the General Design Criteria.
(2) Principle 2: Performance and maintenance deficiency *degraded the level of defense in depth* required for safe operation of the plant.
(3) Principle 3: *Safety margins were not maintained* because the integrity of the RCS pressure boundary relied solely on the vessel lining, which was not designed for this purpose.
(4) Principle 4: *Calculated risk violated the quantitative guideline*.
(5) Principle 5: There was *no basis for assuring that degradations* due to CRDM leaks *would be properly monitored and managed*.

It goes without saying that nobody anticipated in November 2001 the severe vessel wastage that was uncovered in March 2002, which resulted in an unambiguous verdict regarding Principle 3 above. Nonetheless, there were sufficient indications in November 2001 to question if safety margins were not violated, as voiced by a number of the NRC staff before the 28 November 2001 decision. This in turn raises questions if NRC made proper application of RG 1.174 in arriving at the decision to allow a delay of the shutdown of Davis-Besse for the pressure vessel head inspection required in NRC Bulletin 2001-01 [Nrc01c].

During the 11 December 2003 meeting with the NRC staff, the review committee was offered a number of other NRC and industry guidelines that the NRC staff apparently used for the Davis-Besse decision. A review of these additional guidelines further suggests that the NRC value for the incremental CDF = 5.4×10^{-5}/year for seven weeks of additional Davis-Besse operation could not have satisfied these guidelines either. To clarify the point here, we follow the process NRC used to convert the incremental CDF = 5.4×10^{-5}/year to the incremental core damage probability (CDP) for seven weeks or 0.13 year: incremental CDP = 5.4×10^{-5}/year x 0.13 year = 7.0×10^{-6}, rounded off to 5.0×10^{-6}, which is roughly equivalent to approximating 7 weeks as 0.1 year. We may now compare this incremental CDP estimate with three additional guidelines for risk-informed decision-making processes:

(1) RG 1.177 [Nrc98] intended for evaluating Technical Specification changes suggests that an incremental CDP of 5×10^{-7} is acceptable for relaxation of allowed outage time or surveillance test intervals.
(2) PSA Applications Guidelines [Tru95] proposed by the Electric Power Research Institute indicates that an incremental CDP in the range of $[1\times10^{-6}, 1\times10^{-5}]$ requires assessment of non-quantifiable factors.
(3) NUMARC 93-01 [Nei96] suggests that an incremental CDP in the range of $[1\times10^{-6}, 1\times10^{-5}]$ requires risk management actions, adding further that any decisions resulting in an incremental CDP greater than 1×10^{-5} should not be allowed.

Thus, NRC's incremental CDP value of 5×10^{-6} would have resulted in violation of RG 1.177 and would have required risk management actions according to both the EPRI and Nuclear Energy Institute guidelines. In addition, during the 11 December 2003 meeting with the NRC staff, Richard Barrett insisted that the quantitative RG 1.174 guidelines are supposed to be applied in terms of incremental CDP, not incremental CDF as stipulated clearly in the Regulatory Guide. In the February 2004 response [Chu04] to the review committee questions, NRC now proposes that the incremental CDF used as a key metric in RG 1.174 is meant to be an annual average. Thus, NRC now suggests that the incremental CDF = 5.4×10^{-5}/year for 13% of a year should be combined with CDF = 0.0 for the remaining 87% of the year to yield an annual-average incremental CDF = 5×10^{-6}/year. This new interpretation is at best unusual and certainly is inconsistent with clear RG 1.174 guidelines regarding the use of incremental CDF. This reinforces the impression of the review committee that perhaps there was in November 2001 and possibly is still some confusion among the NRC staff regarding basic quantitative metrics that should be considered in evaluating regulatory and safety issues.

A recent release of RG 1.200 [Nrc03] is intended to provide guidance for determining the technical adequacy of PRA results in regulatory decision making. The Regulatory Guide discusses various technical characteristics and attributes that should be included in PRA, and highlights the importance of capturing system dependencies in risk evaluations. RG 1.200 also emphasizes that understanding uncertainties in PRA is an essential aspect of risk characterization and refers to RG 1.174 for guidance on how to address the uncertainties. As reviewed in connection with the DB decision-making process, however, we feel that the guidelines in RG 1.174 are not specific enough, especially for PRA results subject to large uncertainties and for representing events not well understood.

5.2 Technical Specifications and General Design Criteria Regarding Coolant Leak

Davis-Besse technical specification 3.4.6.2 requires that no reactor coolant pressure boundary (RCPB) leakage is allowed. The General Design Criteria, 10 CFR 50 Appendix A, addresses reactor coolant pressure boundary leakage in GDC 14, GDC 31, and GDC 32. GDC 14 specifies that the RCPB have an extremely low probability of abnormal leakage, or rapidly propagating failure, and of gross rupture. GDC 31 specifies that the probability of rapidly propagating fracture of the RCPB be minimized. GDC 32 specifies that components which are part of the RCPB have the capability of being periodically inspected to assess their structural and leaktight integrity.

The FENOC response [Cam01a] to the NRC Bulletin 2001-01 applies the GDC against the situation of potentially cracked nozzles at Davis-Besse. Specifically the following points were made:

- The presence of cracked and leaking vessel head penetration (VHP) nozzles is not consistent with GDC14 or GDC 31.
- Inspection practices that do not permit reliable detection of VHP nozzle cracking are not consistent with GDC 32.

The situation regarding primary coolant leakage can be summarized as follows. The Davis-Besse technical specifications (TS) present a definitive criterion that allows no RCPB leakage. The GDC are not as definitive by virtue of their reference to *probability* of occurrence, which is not an absolute or definitive condition. GDC 14 and 31 are in agreement with the TS in principle, but not in their level of definitiveness. Therefore, there exists the possibility that a specific condition can be considered to satisfy the GDC but not the TS. Furthermore, the GDC implemented in the TS for DB allows for 1 gpm of unidentified reactor coolant system (RCS) leakage and 10 gpm of identified RCS leakage, with the interpretation that leakage past seals, flanges, and gaskets is not pressure boundary leakage.

GDC 32 refers to the capability to inspect the leaktight integrity of the nozzles. Inspections were acknowledged to be incomplete because of failure to inspect all nozzles. They were insufficient because it was acknowledged that visual inspection may be inadequate in detecting cracks. By virtue of the inadequacy of the inspections in achieving their intended purpose, GDC 32 was largely not satisfied.

According to the 2002 OIG Event Inquiry [Bel02], FENOC's own risk-informed evaluation estimated that Davis-Besse had between one and nine leaking CRDM nozzles, depending on the analysis used. According to the NRC, FENOC reported [Nrc02c] an estimate of 8.8 leaking nozzles to ACRS. From the results and analysis of the inspection data from five other B&W plants that revealed 16 cracked nozzles in 15 reactor years of operation [Cam01c] there should be 1-2 leaking nozzles since the last outage (RFO 12 in April 2000). So from the available data, it was *highly likely* that there were leaks in the pressure boundary. These data were circumstantial as there was no direct evidence of the leaks, in part due to the inadequacy of the visual inspection techniques.

Given that positive identification of nozzle leakage was not obtainable because of the nature and capability of the inspections, and given that multiple analyses show that as many as 9 leaking nozzles were likely, it can be concluded that Davis-Besse was *likely* in violation of their Technical Specifications. This point was further discussed in the NRC Significance Assessment Report [Dye03].

The incorporation of PRA into the decision-making process at NRC should have compelled the NRC to consider the likelihood of leaking nozzles in the decision on whether to allow Davis-Besse to continue to operate. However, "the NRR Director told OIG that from a legal point of view, there was an issue about constructing an order without knowing with *certainty* that there were cracks" [Bel02]. This position had a significant impact on the NRC decision as the key decision-maker in this case, Brian Sheron, believed that NRC had no case to shut down the plant based on the technical specification that there be no RCPB leakage. The potential conflict between PRA and legal considerations must be resolved for PRA to play any role in the decision-making process of the NRC.

5.3 Balance between Probabilistic and Deterministic Indicators for Risk Assessment

NRC management is responsible for decision-making. The technical staff is responsible for providing the technical case that serves as the foundation for decisions by

management. The technical case includes both deterministic and PRA analysis that both involve models, data and calculations.

NRC has adopted "risk-informed" decision-making. However, the process is ill-defined and lacks guidelines as to exactly how it is supposed to work. The management does not have a set formula, process or procedure for incorporating PRA into its decision-making process. Brian Sheron was the key decision-maker in the Davis-Besse case. He stated in the December 11 interview with the review team that the PRA analysis was used as a "calibration point" that gives NRC a ballpark figure of the risk. He indicated that the PRA value is not of much consequence unless it is of a "wildly" extreme value. He also indicated that there is little clear guidance on the use of PRA in the decision-making process. This point was supported by comments from Jack Strosnider and Gary Holahan who confirmed in their December 11 interview with the review team that there is no documentation or guidance that outlines to what extent or how the NRC should weigh the resultant risk number and uncertainty with respect to the ultimate decision.

This viewpoint indicates that NRC has no predetermined methodology to weigh the PRA result against a deterministic result or other factors. That is, the value assigned to the PRA analysis is largely at the discretion of the decision-maker and there is no guidance as to the weight to assign to this result. Such a process can result in a decision in which PRA plays a role anywhere from 0 to 100%. Clearly, there is need for the NRC to provide guidance for the use of PRA in decision-making.

6. Review of the November 2001 NRC Decision Regarding Davis-Besse

6.1 Involvement of NRC Staff and Management in the DB Decision

The basis of the November 28 decision to allow Davis-Besse to operate until February 16 was a meeting involving both technical staff and management. The meeting was called by Brian Sheron and was held on November 28, 2001. Following discussion of the various issues regarding Davis-Besse, Brian Sheron asked the staff if they could accept an extension of operation of the plant until February 16, 2002. Three staff members had objections. Mr. Sheron then reframed the question and asked the staff if any of them thought that Davis-Besse was not safe to operate until that date. None thought that this was the case. Based on this result, NRC accepted the February 16, 2002 date proffered by FENOC.

During the discussion, both deterministic analyses and PRA results were considered. However, a cost-benefit type of analysis of the situation was not performed. In an interview with the review team, Richard Barrett explained that NRC followed the RG 1.174 and RIS 2001-02 [Nrc01b] argument, based on a "special circumstance." This special circumstance was that the regulations (ASME inspection codes) at the time were not adequate to detect cracked and/or leaking nozzles and thus NRC had to take special action to address the special circumstance. Once the existence of a special circumstance was established, NRC used RG 1.174 to determine if the problem was risk significant enough. NRC determined that the problem was not risk significant, per RG 1.174, because "defense-in-depth" was preserved. Therefore, NRC did not consider the third factor, which would have been "higher level NRC management thoughts," such as a "cost-benefit" analysis or impact/burden on license.

However, as noted by several staff, there was pressure on the NRC from industry, Congress and the NRC Commissioners to keep plants running. It is not clear how much influence this pressure had on the decision-making process.

The transparency of the decision-making process within NRC is not uniform. In the case of a shutdown order, the Executive Director for Operations (Office Director) would be the official responsible for signing the order. If the issue does not involve an order, the process is less clear. The specification of decision-maker appears to depend on the importance of the issue. There does not appear to be a policy that identifies what individuals are empowered to make what decisions. Strosnider and Holahan indicated that a routine response to a generic letter may be handled by a project manager, or perhaps by the Divisions of Licensing Project Management, with the concurrence of the involved sections or other divisions. NRC has no standard process or guidelines for decision-making. Sometimes the decision process involves a memo describing the licensee's request and NRC's response that is routed around and signed off on by relevant NRC staff. Other times, NRC will pull together a meeting of decision stakeholders.

The lack of an established and well-defined process for decision-making within the agency is a significant problem that needs to be addressed.

6.2 Coordination among NRR, RES, and Inspectors

The analysis and decision-making process for the Davis-Besse case involved numerous individuals and offices. Included in the consideration of issues regarding Davis-Besse were the Directorate for Project Licensing & Technical Analysis, the Division of Engineering, and Division of System Safety and Analysis and the technical staff of the several Branches that report to those Division Directors of the Office of Nuclear Reactor Regulation (NRR). In addition, the Office of Research (RES) and ACRS played roles, as did the regional office and the regional inspector at Davis-Besse.

While there were a number of individuals and offices involved in the technical assessment of nozzle cracking, the interplay between offices and individuals is impossible to reconstruct. However, there are two cases that highlight problems with communication between offices and between individuals. The first is in the assessment of the initiating event probability. Based on interviews with some 12 different individuals, all significantly involved in the Davis-Besse issue and analysis, and spanning two Offices, one Directorate, two Divisions and several Branches, there was no sense of understanding about how the initiating event probability used in the PRA analysis was determined and by whom. In fact, the origin of the value for the initiating event probability that appears to have been used in the PRA analysis was variously ascribed to Bill Shack at ANL, FENOC, Framatome and EMC[2]. Further, the perception of who within NRC was responsible for establishing this quantity was not consistent. This situation indicates a very uneven understanding of one of the key underlying quantities for the entire PRA analysis. The origin of this term remains an outstanding issue, even with the February 2004 NRC response [Chu04]. It was clear that there was substantial interaction among offices and individuals during the period of intense analysis in the Fall of 2001. However, communication did not appear to be well structured, complete or effective in establishing a value for the initiating event probability.

A second problem was evident in the communication between the various components (headquarters, regional office, regional inspector at Davis-Besse) of the NRC. The resident inspector appears to have played little or no role in providing information relevant to the issues being analyzed at NRC HQ. Further, there appears to have been no communication between the resident inspector and HQ. In the December 11th interview with the review team, Mr. Strosnider stated that it was rare one would think a resident inspector would offer substantive help. He did not believe that the resident inspector at Davis-Besse was, in fact, contacted. He also believed that the resident inspector is busy with other things, and that he probably had not been part of the

vessel head inspections, and that he lacked the technical aptitude needed to contribute to the issue.

There were several indications of operational irregularities that should have been noted by an inspector in residence at the plant. These include: 1) radiological surveys showing a contamination plume effect originating from the service structure ventilation exhaust over the East D-ring [Dye02], 2) significant increase in the cleaning of containment air coolers, 3) the removal of fifteen, 5-gallon buckets of boric acid from the ductwork and plenum of the containment air coolers and the discovery of significant boric acid elsewhere in the containment, such as service water piping, stairwells, and other areas of low ventilation, and 4) the sudden change to rust-colored boric acid in June of 1999. That these events were occurring without the knowledge or appreciation of the resident NRC inspector highlights a major weakness of the role of the resident inspector in helping to ensure safe operation of the plant at which he/she is stationed.

6.3 Arbitrariness of the Requested Shutdown Date

The 12/31/01 date for completing inspections of reactor vessel head nozzles imposed on licensees by the NRC was arbitrarily set. The arbitrariness of the 12/31/01 date was confirmed by Brian Sheron in his interview with the review committee in which he stated that there was nothing magical about the December 31st date, and that it just as easily could have been February 28th or March 31st.

The arbitrariness of the date caused difficulty for the NRC when challenged by FENOC. The challenge resulted in a perceived reversal of the burden of proof from the licensee to the NRC. NRC believed that they needed to make a case in order to force a shutdown of DB to look for cracks. Unfortunately, their authority to act was perceived to be undermined by the lack of a defensible rationale for the selection of the inspection date.

NRC has been encouraging the use of risk analysis as part of the risk-informed decision-making process. Yet NRC did not consider including risk analysis in the original call for inspection. The inclusion of risk analysis in the formulation of the inspection date could have provided the NRC with the justification for enforcement that they lacked under the present circumstances. If the call for inspection were based on a risk-informed decision-making strategy, then the calculations of the likelihood of nozzle failure and LOCA would have provided the support they needed to call for an inspection. The practical considerations in this strategy are not trivial. Yet had NRC followed its commitment to incorporate risk analysis in its decision-making process at the outset, the decision regarding Davis-Besse may have been much more straightforward.

6.4 The Role of NRC's Advisory Committee on Reactor Safeguards

Although we recognize that ACRS does not provide routine guidance on plant-specific issues, we feel that NRC staffs should have recognized the CRDM nozzle failures as a generic issue and should have solicited in-depth assistance from ACRS before the 28 November 2001 decision. Thus, relying on a narrow interpretation of the CRDM nozzle failure issues, the staff missed an opportunity to obtain important expert perspectives on the issues. We recommend that the NRC staff make more direct use of ACRS to augment in-house expertise on the staff, which may be limiting at times.

6.5 NRC Staff Workload Affecting Its Ability for Detailed Risk Assessment

An NRC manager raised the question if NRC had sufficient personnel, given the workload, to perform detailed studies on complex regulatory or licensing issues such as the Davis-Besse case. Although the upper level management seems to be satisfied with the overall staff performance, we recommend a review of the workload and technical competence of the staff required to provide licensing and regulatory support in a timely manner.

6.6 Davis-Besse, NRC, and Three Mile Island

The human errors on the parts of Davis-Besse and NRC, resulting in a near miss of a serious accident, echo a similar chain of events that originated at Davis-Besse in 1977 and culminated in America's most serious reactor accident at Three Mile Island in 1979. It began in September 1977 at Davis-Besse when a relief valve on the reactor coolant pressurizer stuck open. The coolant pressure fell but the water level in the pressurizer increased, the result of an anomaly in the pressurizer piping. Thinking that the reactor was getting too much water, the operator improperly interfered with the high-pressure injection system. Fortunately, a supervisor recognized what was happening and closed the relief valve twenty minutes later and re-admitted coolant. No damage was done to the reactor because it had been operating at only 9 percent power.

The incident was investigated by both NRC and by B&W, the reactor supplier, but no information calling attention to the correct operating actions was provided to other utilities. A B&W engineer had stated in an internal memorandum that if the Davis-Besse event had occurred in a reactor operating at full power, "it is quite possible, perhaps probable, that core uncovering and possible fuel damage would have occurred."

In 1978 an NRC official pointed out the likelihood of erroneous operator action in B&W reactors. The NRC did not notify utilities about the lessons learned at Davis-Besse and the pressing need for new training to avoid the confusing interpretation of water level indicators at B&W plants. Fourteen months later the core-melt accident happened at Three Mile Island.

In March 1979, a similar B&W reactor was operating at full power at Three Mile Island in Pennsylvania. Again, the pressure relief valve stuck open, reactor coolant escaped, coolant pressure fell and the operators made the same mistake as had the operators two years earlier at Davis-Besse. They turned off the high-pressure coolant injection. Unfortunately, the ensuing control room confusion did not lead to early diagnosis and restoration of reactor water. With the high-pressure injection water incorrectly turned off, the reactor continued to generate heat and boil coolant, ultimately uncovering the reactor core and melting a substantial portion of the reactor fuel. When a supervisor finally diagnosed the problem and restored high-pressure injection water, some two hours later, enormous fuel damage had been done and considerable radioactivity released to the reactor building.

The President's Commission on the Accident at Three Mile Island [Kem79] concluded that the major factor that turned the TMI incident into a serious accident was inappropriate operator action, deficiencies in training and failure of responsible organizations, especially the NRC, to learn the proper lessons from previous incidents. There was a serious lack of recognition of the safety implications of new information and there was serious lack of questioning of the adequacy of assumptions made in the reactor design, in the operating procedures, and in the follow up of events. The Commission concluded that, starting with the Davis-Besse 1977 event and given all the deficiencies of the safety system and its regulation, an accident like Three Mile Island was eventually inevitable.

For many months and even years it was not realized that the TMI accident had resulted in such extensive core damage. More responsive earlier analyses by NRC of the 1977 Davis-Besse precursor event and its potential consequences would have alerted NRC to forewarn the utilities of the incipient danger. Similarly, the seeming lack of aggressive followup by NRC and industry to understand the risks from the recent near miss at Davis-Besse is a serious concern. History should not be allowed to repeat itself.

7. Recommendations for Improved Use of Probabilistic Risk Assessment

There are several ways in which NRC can improve the use of PRA in its decision-making process:

(1) Establish an appreciation for PRA across the spectrum of NRC technical and managerial personnel. There is great divergence in the appreciation for, and understanding of PRA and its value in the decision-making process. In a sense, NRC needs to get their staff "on the same page" with regard to PRA applications in regulatory and licensing issues.

(2) Establish a set of guidelines for the use of PRA in decision-making. No guidelines currently exist for how PRA should be incorporated into the decision-making process other than the general philosophy that risk analysis should be part of a risk-informed decision-making process. A set of guidelines that establishes the level and nature of consideration of PRA is needed. In particular, guidance should be provided on how to balance PRA results against deterministic or qualitative evaluations, especially when the PRA results are subject to large uncertainties.

(3) Establish a set of guidelines for how decisions are made at NRC and by whom. This is a necessary precursor to the success of recommendation 2. The decision-making process must be defined in order to incorporate risk analysis into that process. Further, the offices and individuals responsible for making decisions need to be defined in order to successfully determine who needs to be aware of and familiar with PRA as discussed in recommendation 1.

(4) Establish a better protocol for estimating and incorporating uncertainties in PRA. PRA results without associated uncertainties are of little value. As a result, it is difficult to incorporate results of an analysis into a decision strategy without an understanding of the bounds of the validity of the result.

(5) Provide for unanticipated events. Corrosion of the Davis-Besse pressure vessel head was not an anticipated event. As put by NRC personnel, it was not even on the radar screen. As such, it was not incorporated into the event tree analysis in PRA. However, PRA needs to be able to anticipate the consequences of such oversight.

(6) Establish a better system at NRC for recognizing generic problems and transmitting information and concerns about these potential problems to other plants.

(7) NRC should issue preliminary analyses of risks from nozzle cracking that include leakage through axial cracks, evaporation of leaking coolant, concentration of and corrosion by boric acid, corrosion of the carbon-steel vessel and the vessel liner, the time-dependent probability of rupture of the corroded vessel, core damage resulting from loss of coolant, and the effects of human failure to make and interpret surveillance inspections. The results and possible interpretations of the recent Oak Ridge tests of vessel failure should be made known to the safety community.

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Davis-Besse Task Force Recommendations to NRC and Their Status, as of March 2004

Recommendation	NRC actions and status as of March 2004
Completed recommendations	
Either fully implement or revise guidance to manage licensee commitments. Determine whether the periodic report on commitment changes submitted by licensees should continue.	Revised instructions for these submittals and reviews to ensure that these tasks are accomplished. Completed in May 2003.
Determine if stress corrosion cracking models are appropriate for predicting susceptibility of vessel head penetration nozzles to pressurized water stress corrosion cracking. Determine if additional analysis and testing is needed to reduce modeling uncertainties for their continued applicability in regulatory decision making.	Evaluated existing stress corrosion cracking models for their continuing use in determining susceptibility. Completed in July 2003.
Revise the problem identification and resolution approach so that safety problems noted in daily licensee reports are reviewed and assessed. Enhance guidance to prescribe the format of information that is screened when deciding which problems to review.	Revised inspection procedure for determining licensee ability to promptly identify and resolve conditions adverse to quality or safety. Completed in September 2003.
Provide enhanced inspection guidance to pursue issues and problems identified during reviews of plant operations.	Revised inspection procedure for determining licensee capability to promptly identify and resolve conditions adverse to quality or safety. Completed in September 2003.
Revise inspection guidance to provide for longer-term follow-up of previously identified issues that have not progressed to an inspection finding.	Revised inspection procedure for determining licensee capability to promptly identify and resolve conditions adverse to quality or safety. Completed in September 2003.
Revise inspection guidance to assess (1) the safety implications of long-standing unresolved licensee equipment problems, (2) the impact of phased in corrective actions, and (3) the implications of deferred plant modifications.	Revised inspection procedure for determining licensee capability to identify and resolve conditions adverse to quality or safety. Completed in September 2003.
Revise inspection guidance to allow for establishing reactor oversight panels even when a significant performance problem, as defined under NRC's Reactor Oversight Process, does not exist.	Revised inspection guidance for establishing reactor oversight panels. Completed in October 2003.
Assess the scope and adequacy of requirements for licensees to review operating experience.	Included in NRC's recommendation to develop a program for collecting, analyzing, and disseminating information on experiences at operating reactors. Completed in November 2003.
Ensure inspector training includes (1) boric acid corrosion effects and control, and (2) pressurized water stress corrosion cracking of nickel-based alloy nozzles.	Developed and implemented Web-based training and a means for ensuring training is completed. Completed in December 2003.
Provide training and reinforce expectations to managers and staff to (1) maintain a questioning attitude during inspection activities, (2) develop inspection insights from Davis-Besse on symptoms of reactor coolant leakage, (3) communicate expectations to follow up recurring and unresolved problems, and (4) maintain an awareness of surroundings while conducting inspections. Establish mechanisms to perpetuate this training.	Developed Web-based inspector training and a means for ensuring that training has been completed. NRC headquarters provided an overview of the training to NRC regional offices. (Training modules will be added and updated as needed.) Completed in December 2003.
Reinforce expectations that regional management should make every effort to visit each reactor at least once every 2 years.	Discussed at regional counterparts meeting. Completed in December 2003.
Develop guidance to address impacts of regional oversight panels on regional resource allocations and organizational alignment.	Evaluated past and present oversight panels. Developed enhanced inspection approaches for oversight panels and issued revised procedures. Completed in December 2003.

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Recommendation	NRC actions and status as of March 2004
Evaluate (1) the capacity to retain operating experience information and perform long-term operating experience reviews; (2) thresholds, criteria, and guidance for initiating generic communications; (3) opportunities for more gains in effectiveness and efficiency by realigning the organization (i.e., feasibility of a centralized operating experience "clearinghouse"); (4) effectiveness of the generic issues program; and (5) effectiveness of internal dissemination of operating experience information to end users.	Developed program objectives and attributes and obtained management endorsement of a plan to implement the recommendation. Developed specific recommendations to improve program. Evaluation completed in November 2003. (Implementation of recommendations resulting from this evaluation expected to be completed in December 2004.)
Ensure that generic requirements or guidance are not inappropriately affected when making unrelated changes to other programs, processes, guidance, etc.	Revised inspection guidance. Completed in February 2004.
Develop inspection guidance to assess scheduler influences on amount of work performed during refueling outages.	Revised the appropriate inspection procedure. Completed in February 2004.
Establish guidance to ensure that NRC decisions allowing licensees to deviate from guidelines and recommendations issued in generic communications are adequately documented.	Update guidance to address documentation. Develop training and distribute to NRC offices and regions to emphasize compliance with the updated guidance. Follow up to assess the effectiveness of the training. Completed follow-up in February 2004.
Develop or revise inspection guidance to ensure that NRC reviews vessel head penetration nozzles and the reactor vessel head during licensee inspection activities.	Develop or revise inspection guidance to ensure that nozzles and the vessel head are reviewed during licensee inspection. Issued interim guidance in August 2003 and a temporary inspection procedure in September 2003. Additional guidance expected in March 2004.
Develop inspection guidance to assess (1) repetitive or multiple technical specification actions in NRC inspection or licensee reports, and (2) radiation dose implications for conducting repetitive tasks.	Revise the appropriate inspection procedure to reflect this need. Completion expected in March 2004.
Develop guidance to periodically inspect licensees' boric acid corrosion control programs.	Issued temporary guidance in November 2003. Completion of further inspection guidance changes expected in March 2004.
Reinforce expectations for managers responsible for overseeing operations at nuclear power plants regarding site visits, coordination with resident inspectors, and assignment duration. Reinforce expectations to question information about operating conditions and strengthen guidance for reviewing license amendments to emphasize consideration of current system conditions, reliability, and performance data in safety evaluation reports. Strengthen guidance for verifying licensee-provided information.	Update project manager handbook that provides guidance on activities to be conducted during site visits and interactions with NRC regional staff. Also, revise guidance for considering plant conditions during licensing action and amendment reviews. Completion expected in March 2004.
Assemble and analyze foreign and domestic information on Alloy 600 nozzle cracking. If additional regulatory action is warranted, propose a course of action and implement a schedule to address the results.	Assemble and analyze alloy 600 cracking data. Completion expected in March 2004.
Recommendations due to be completed between April and December 2004	
Conduct an effectiveness review of actions taken in response to past NRC lessons-learned reviews.	Review past lessons-learned actions. Completion expected in April 2004.
Provide inspection and oversight refresher training to managers and staff.	Develop a training module. Completion expected in June 2004.

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Recommendation	NRC actions and status as of March 2004
Establish guidance for accepting owners group and industry recommended resolutions for generic communications and generic issues, including guidance for verifying that actions are taken.	Revise office instructions to provide recommended guidance. Completion expected in June 2004.
Review inspection guidance to determine the inspection level that is sufficient during refueling outages, including inspecting reactor areas inaccessible during normal operations and passive components.	Revised an inspection procedure to reflect these changes. Some inspection procedure changes were completed in November 2003, and additional changes are expected in August 2004.
Evaluate, and revise as necessary, guidance for proposing candidate generic issues.	Evaluate and revise guidance. Completion expected in October 2004
Assemble and analyze foreign and domestic information on boric acid corrosion of carbon steel. If additional regulatory action is warranted, propose a course of action and implement a schedule to address the results.	Review Argonne National Laboratory study on boric acid corrosion. Analyze data to revise inspection requirements. Completion expected in October 2004.
Conduct a follow-on verification of licensee actions to implement a sample of significant generic communications with emphasis on those that are programmatic in nature.	Screen candidate generic communications to identify those most appropriate for follow-up using management-approved criteria. Develop and approve verification plan. Completion expected in November 2004.
Strengthen inspection guidance for periodically reviewing licensee operating experience.	Incorporated into the recommendation pertaining to NRC's capacity to retain operating experience information. Completion expected in December 2004.
Enhance the effectiveness of processes for collecting, reviewing, assessing, storing, retrieving, and disseminating foreign operating experience.	Incorporated into the recommendation pertaining to NRC's capacity to retain operating experience information. Completion expected in December 2004.
Update operating experience guidance to reflect the changes implemented in response to recommendations for operating experience.	Incorporated into the recommendation pertaining to NRC's capacity to retain operating experience information. Completion expected in December 2004.
Review a sample of NRC evaluations of licensee actions made in response to owners groups' commitments to identify whether intended actions were effectively implemented.	Conduct the recommended review. Completion expected in December 2004.
Develop general inspection guidance to periodically verify that licensees implement owners groups' commitments.	Develop inspection procedure to provide a mechanism for regions to support project managers' ability to verify that licensees implement commitments. Completion expected in December 2004.
Conduct follow-on verification of licensee actions pertaining to a sample of resolved generic issues.	No specific actions have been identified. Completion expected in December 2004.
Review the range of baseline inspections and plant assessment processes to determine sufficiency to identify and dispose of problems like those at Davis-Besse.	No specific actions have been identified. Completion expected in December 2004.
Identify alternative mechanisms to independently assess licensee plant performance for self-assessing NRC oversight processes and determine the feasibility of such mechanisms.	No specific actions have been identified. Completion expected in December 2004.
Establish measurements for resident inspector staffing levels and requirements, including standards for satisfying minimum staffing levels.	Develop standardized staffing measures and implement details. Metrics were developed in December 2003. Completion expected in December 2004.
Structure and focus inspections to assess licensee employee concerns and a "safety conscious work environment."	No specific actions have been identified. Completion expected in December 2004.

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Recommendation	NRC actions and status as of March 2004
Recommendations due to be completed in calendar year 2005	
Develop inspection guidance and criteria for addressing licensee response to increasing leakage levels and/or adverse trends in unidentified reactor coolant system leakage.	Develop recommendations for guidance with action levels to trigger greater NRC interaction with licensees in response to increased leakage. Completion expected in January 2005.
Reassess the basis for the cancellation, in 2001, of certain inspection procedures (i.e., boric acid control programs and operational experience feedback) to assess if these procedures are still applicable.	Review revised procedures and reactivate as necessary. Completion expected in March 2005.
Assess requirements for licensee procedures to respond to plant alarms for leakage to determine whether requirements are sufficient to identify reactor coolant pressure boundary leakage.	Review and assess adequacy of requirements and develop recommendations to (1) improve procedures to identify leakage from boundary, (2) establish consistent technical specifications for leakage, and (3) use enhanced leakage detection systems. Completion expected in March 2005.
Determine whether licensees should install enhanced systems to detect leakage from the reactor coolant system.	Re-evaluate the basis for current leakage requirements and assess the capabilities of current leakage detection systems. Develop recommendations to (1) improve procedures for identifying leakage, (2) establish consistent technical specifications, and (3) use enhanced leakage detection systems. Completion expected in March 2005
Inspect the adequacy of licensee's programs to control boric acid corrosion, including effectiveness of implementation.	Develop guidance to assess adequacy of corrosion control programs, including implementation and effectiveness, and evaluate the status of this effort after the first year of inspections. Guidance expected to be developed by March 2004. Follow-up scheduled for completion in March 2005.
Continue ongoing efforts to review and improve the usefulness of barrier integrity performance indicators and evaluate the use of primary system leakage that licensees have identified but not yet corrected as a potential indicator.	Develop and implement improved performance indicators based on current requirements and measurements. Explore the use of additional performance indicators to track the number, duration, and rate of system leakage. Determine the feasibility of establishing a risk-informed performance indicator for barrier integrity. Completion expected in December 2005.
Recommendations whose completion dates have yet to be determined	
Encourage the American Society of Mechanical Engineers to revise inspection requirements for nickel-based alloy nozzles. Encourage changes to requirements for nonvisual, nondestructive inspections of vessel head penetration nozzles. Alternatively, revise NRC regulations to address the nature and scope of these inspections.	Monitor and provide input to industry efforts to develop revised inspection requirements. Participate in American Society of Mechanical Engineers' meetings and communicate with appropriate stakeholders. Decide whether to endorse the revised American Society of Mechanical Engineers' code requirements. These actions parallel a larger NRC rulemaking effort. Completion date yet to be determined.
Revise processes to require short- and long-term verification of licensee actions to respond to significant NRC generic communications before closing out issues.	Target date to be set upon completion of review of NRC's generic communications program. Completion date yet to be determined.
Determine whether licensee reactor vessel head inspection summary reports should be submitted to NRC and, if so, revise submission requirements and report disposition guidance, as appropriate.	Will be included as part of revised American Society of Mechanical Engineers' requirements for inspection of reactor vessel heads and vessel head penetration nozzles. Completion date yet to be determined.

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Recommendation	NRC actions and status as of March 2004
Evaluate the adequacy of methods for analyzing the risk of passive component degradation and integrate these methods and risks into NRC's decision-making processes.	No specific actions have been identified. Completion date yet to be determined.
Review pressurized water reactor technical specifications to identify plants that have nonstandard reactor coolant pressure boundary leakage requirements and change specifications to make them consistent among all plants.	Assessed plants for nonstandard technical specifications. Completed in July 2003. Change leakage detection specifications in coordination with other changes in leakage detection requirements. Completion date yet to be determined.
Improve requirements for unidentified leakage in reactor coolant system to ensure they are sufficient to (1) discriminate between unidentified leaks from the coolant system and leaks from the reactor coolant pressure boundary and (2) ensure that plants do not operate with pressure boundary leakage.	Issue regulations implementing the improved requirements when these requirements are determined. Completion date yet to be determined.
NRC should review a sample of plant assessments conducted between 1998 and 2000 to determine if any identified plant safety issues have not been adequately assessed.	No specific actions have been identified. Completion expected in March 2004.
Recommendations rejected by NRC management	
Review industry approaches licensees use to consider economic factors for inspection and repair and consider this information in formulating future positions on the performance of non-visual inspections of vessel head penetration nozzles.	Recommendation rejected by NRC management. No completion date.
Revise the criteria for review of industry topical reports to allow for NRC staff review of safety-significant reports that have generic implications but have not been formally submitted for NRC review in accordance with the existing criteria.	Recommendation rejected by NRC management. No completion date.

Source: GAO analysis of NRC data.

Comments from the Nuclear Regulatory Commission

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

May 5, 2004

Mr. James Wells, Director
Natural Resources and Environment
United States General Accounting Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Wells:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am responding to your letter of April 2, 2004, requesting the NRC's review of the draft report entitled "Nuclear Regulation: NRC Needs to More Aggressively and Comprehensively Resolve Issues Related to the Davis-Besse Nuclear Power Plant's Shutdown" (GAO-04-415). I appreciate the opportunity to provide comments to the General Accounting Office (GAO) on this report.

I am concerned that the draft report does not appropriately characterize or provide a balanced perspective on the NRC's actions surrounding the discovery of the Davis-Besse reactor vessel head condition or NRC's actions to incorporate the lessons learned from that experience into our processes. The NRC also does not agree with two of the report's recommendations, as discussed in the following paragraphs.

See comment 1.

The first sentence of the draft report states: "...oversight did not generate accurate, complete information on plant conditions." I agree that our oversight program should have identified certain evolving plant conditions for regulatory follow-up. This was also identified in the report of the Davis-Besse Lessons Learned Task Force (LLTF) that the NRC formed to ensure that lessons from the Davis-Besse experience are learned and appropriately captured in the NRC's formal processes. However, the draft report does not acknowledge that the NRC, in carrying out its safety responsibilities, must rely heavily on our licensees to provide us with complete and accurate information. In fact, Title 10 of the Code of Federal Regulations Section 50.9 requires that information provided to the NRC by a licensee be complete and accurate in all material respects. The report should clearly indicate that NRC's licensees are responsible for providing us with accurate and complete information. While the NRC's Davis-Besse LLTF concluded that the NRC, the Davis-Besse licensee (FirstEnergy), and the nuclear industry failed to adequately review, assess, and follow up on relevant operating experience, they also noted that the information that FirstEnergy provided in response to Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles" was inconsistent with information identified by the task force. Further, the LLTF report stated that had this information been known in the fall of 2001, "...the NRC may have identified the VHP [vessel head penetration] nozzle leaks and RPV [reactor pressure vessel] head degradation a few months sooner than the March 2002 discovery by the licensee." As you are aware, there is an ongoing investigation by the Department of Justice regarding the completeness and accuracy of information that FirstEnergy provided to the NRC on the condition of Davis-Besse.

See comment 2.

The NRC is particularly concerned about the draft report's characterization of the NRC's use of risk estimates. The statement in the report that the NRC's "estimate of risk exceeded the risk

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levels generally accepted by the agency" is not factually correct. NRC officials pointed out to GAO and GAO's consultants, both in interviews and in written responses to GAO questions, that our estimate of delta core damage frequency was $5x10^{-6}$ per reactor year, not $5x10^{-5}$ per reactor year as indicated in the report. In fact, the NRC staff safety evaluation (attached to a December 3, 2002, letter to FirstEnergy) stated that the change in core damage frequency due to the potential for control rod drive mechanism nozzle ejection was consistent with the guidelines of Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis." The enclosure to this letter provides detailed comments on issues of correctness and clarity in the report, many of which are related to the NRC's estimate of risk at Davis-Besse.

See comment 3.

We disagree with the finding that the NRC does not have specific guidance for deciding on plant shutdowns and with the report's related recommendation identifying the need for NRC to develop specific guidance and a well-defined process for deciding when to shut down a nuclear power plant. We believe our regulations, guidance, and processes that cover whether and when to shut down a plant are robust and do, in fact, provide sufficient guidance in the vast majority of situations. Plant technical specifications, as well as many other NRC requirements and processes, provide a spectrum of conditions under which plant shutdown would be required. Plants have shut down numerous times in the past in accordance with NRC requirements. From time to time, however, a unique situation may present itself wherein sufficient information may not exist or the information available may not be sufficiently clear to apply existing rules and regulations definitively. In these unique instances, the NRC's most senior managers, after consultation with staff experts and given all of the information available at the time, will decide whether or not to require a plant shutdown. Risk information is used in accordance with Regulatory Guide 1.174. This process considers deterministic factors as well as probabilistic factors (i.e., risk information). We regard the combined use of deterministic and probabilistic factors to be a strength of our decision-making process.

See comment 4.

Another issue identified in the draft report as a systemic weakness is that the NRC has not proposed specific actions to address a licensee's commitment to safety, also known as safety culture. We disagree with the report's recommendation that NRC should develop a methodology to assess licensees' safety culture that includes indicators of and/or information on patterns of licensee behavior, as well as on licensee organizational structures and processes. To date, the Commission has specifically decided not to conduct direct evaluations or inspections of safety culture as a routine part of assessing licensee performance due to the subjective nature of such evaluations. As regulators, we are not charged with managing our licensees' facilities. Direct involvement with safety culture, organizational structure, and processes crosses over to a management function. The NRC does conduct a number of assessments that adequately evaluate how effectively licensees are managing safety. These include an inspection procedure for assessing licensees' employee concerns programs, the NRC allegation program, enforcement of employee protection regulations, and safety-conscious work environment assessments during problem identification and resolution (PI&R) inspections. In addition, the NRC's LLTF made several recommendations (which are being addressed) to enhance the NRC's capability in this area. The NRC does not assess, nor does it plan to assess, licensee management competence, capability, or optimal organizational structure as part of safety culture.

See comment 5.

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While there are a number of factual errors in the draft report, as noted in the enclosure, we agree with many of the findings in the draft report. Most of GAO's findings are similar to the findings of the NRC's Davis-Besse LLTF. The NRC staff has made significant progress in implementing actions recommended by the LLTF and expects to complete implementation of more than 70 percent of them, on a prioritized basis, by the end of calendar year 2004. Reports tracking the status of these actions are provided to the Commission semiannually and will continue until all items are completed, at which time a final summary report will be issued.

I have enclosed the NRC's detailed comments on the draft report. If you have any questions, please contact Stacey L. Rosenberg, of my staff, at (301) 415-3868.

Sincerely,

William D. Travers for
Executive Director
for Operations

Enclosure:
1. NRC Comments on GAO Draft Report on Davis-Besse
2. Memorandum from EDO to OIG dated April 19, 2004

See comment 1.

See comment 2.

NRC Comments on Draft Report, GAO-04-415

1. The draft report does not speak to a key issue, the responsibility of licensees to provide complete and accurate information to the NRC. In carrying out its safety responsibilities, NRC must rely heavily on our licensees to provide us with complete and accurate information. Title 10 of the Code of Federal Regulations Section 50.9 requires that information provided to the NRC by a licensee be complete and accurate in all material respects. By not recognizing this explicitly and its role in this matter, the draft report conveys the expectation that the NRC staff should have known about the thick layer of boron on the reactor vessel head. The Davis-Besse Lessons Learned Task Force (LLTF), which NRC formed to ensure that lessons from the Davis-Besse experience are learned and appropriately captured in the NRC's formal processes, noted that the information that FirstEnergy provided in response to Bulletin 2001-01, "Circumferential Cracking of Reactor Pressure Vessel Head Penetration Nozzles" was inconsistent with information identified by the task force. Further, the LLTF report stated that had this information been known in the fall of 2001, the NRC may have identified the vessel head penetration (VHP) nozzle leaks and reactor pressure vessel (RPV) head degradation a few months sooner than the March 2002 discovery by the licensee. See also the related information in response #2.

2. Page 7, first sentence of the last paragraph states: ***"NRC should have but did not identify or prevent the vessel head corrosion at Davis-Besse because both its inspections at the plant and its assessments of the operator's performance yielded inaccurate and incomplete information on plant safety conditions."***
Response: This statement is misleading. We agree that our oversight program should have identified certain evolving plant conditions for regulatory follow-up. This was also

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identified in the report of the Davis-Besse Lessons LLTF. It is the responsibility of licensees to provide the NRC with complete and accurate information. In fact, Title 10 of the Code of Federal Regulations Section 50.9 requires that information provided to the NRC by a licensee be complete and accurate in all material respects. The report should clearly indicate that NRC's licensees are responsible for providing us with accurate and complete information. While the NRC's Davis-Besse LLTF concluded that the NRC, the Davis-Besse licensee (FirstEnergy), and the nuclear industry failed to adequately review, assess, and follow up on relevant operating experience, the LLTF also noted that the information that FirstEnergy provided in response to Bulletin 2001-01 was inconsistent with information identified by the task force. Further, the LLTF report stated that had this information been known in the fall of 2001, the NRC may have identified the vessel head penetration nozzle leaks and the reactor vessel head degradation a few months sooner than the March 2002 discovery by the licensee. As you are aware, there is an ongoing investigation by the Department of Justice regarding the completeness and accuracy of information that FirstEnergy provided to the NRC on the condition of Davis-Besse.

See comment 3.

3. Page 8, last sentence states: ***"Further, the risk estimate indicated that the likelihood of an accident occurring at Davis-Besse was greater than the level of risk generally accepted as being reasonable by NRC."***

Response: This is incorrect. NRC staff explained to the GAO consultants that NRC guidance produces an estimate for the change in core damage frequency of $5x10^{-6}$ per year, not $5x10^{-5}$ as indicated in the GAO report. According to Regulatory Guide (RG) 1.174, for Davis-Besse, this estimate is within acceptable bounds. NRC specifically documented the acceptability of the estimate in the December 2002 assessment. Thus, the December 3, 2002, safety evaluation concluded that the delta core damage frequency was consistent with the guidelines of RG 1.174.

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See comment 6.

4. Page 15 states that borax (i.e., sodium borate) is dissolved in the water. This is incorrect. Please replace the word "borax" with "boric acid crystals."

See comment 7.

5. Page 18, first full paragraph states: ***"NRC, in deciding on when FirstEnergy had to shutdown Davis-Besse for the inspection,..."***
Response: In addition, the staff relied upon information provided by the licensee regarding the condition of the vessel head (i.e., previous leakage and action taken to repair leaks and clean the vessel head).

See comment 8.

6. Page 26, beginning on line 4, states: ***"According to the NRC regional branch chief—who supervised the staff responsible for overseeing FirstEnergy's vessel head inspection activities during the 2000 refueling outage—he was unaware of the boric acid leakage issues at Davis-Besse, including its effects on the containment air coolers and the radiation monitor filters."***
Response: According to the individual to whom this statement is attributed, the statement would be correct if the phrase, "he was unaware...filters" is changed to "he was unaware that boric acid was found on the reactor vessel head during the outage."

See comment 9.

7. Page 27, first sentence states: ***"Similarly, NRC officials said that NRC headquarters had no systematic process for communicating information in a timely manner to its regions or on-site inspectors."***
Response: If the "information" in question refers to issues of potential safety significance into which inspectors should look, then this statement is inaccurate. The systematic process for temporarily focusing inspection activity in a coordinated program-wide manner on high-priority issues is the "Temporary Instruction" (TI) process, which is well established within the NRC Inspection Manual and frequently used. The legitimate point

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to be made is that until the Davis-Besse event, the NRC had not concluded that boric acid corrosion was a sufficient safety concern that reached the threshold for using the TI process.

8. Page 33, middle paragraph states: ***"For example, concern over alloy 600 cracking led France, as a preventive measure, to develop plans for replacing all of its reactor vessel heads and installing removable insulation to better inspect for cracking."***

See comment 10.

<u>Response</u>: French regulators instituted requirements for an extensive, non-visual nondestructive examination inspection program for vessel head penetration nozzles that resulted in plant operators deciding, on the basis of economic considerations, to replace vessel heads in lieu of conducting such examinations.

9. Page 34, last paragraph states: ***"If such small leakage can result in such extensive corrosion..."***

See comment 11.

<u>Response</u>: Small leakage alone was not the cause of the corrosion. It was a combination of prolonged leakage in conjunction with allowing caked-on boron to remain on the vessel head.

10. Page 36, middle paragraph states: ***"However, NRC decided that it could not order Davis-Besse to shut down on the basis of other plants' cracked nozzles and identified leakage or the manager's acknowledgment of a probable leak. Instead, it believed it needed more direct, or absolute, proof of a leak to order a shutdown."***

See comment 12.

<u>Response</u>: As discussed at the NRC-GAO exit conference, plant Technical Specifications, as well as many other NRC requirements and processes, provide a number of circumstances in which a plant shutdown would or could be required, including the existence of reactor coolant pressure boundary leakage while operating at power.

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Please note that there was no legal objections to the draft order and the stated basis for deciding to not issue the order was not an insufficient legal basis.

11. Page 36, last paragraph states: ***"...NRC does not have specific guidance for shutting down a plant when the plant may pose a risk to public health and safety even though it may be complying with NRC requirements."***

See comment 4.

Response: We disagree with this finding and with the report's related recommendation on Page 63 identifying the need for NRC to develop specific guidance and a well-defined process for deciding when to shut down a nuclear power plant. We believe our regulations, guidance, and processes that cover whether and when to shut down a plant are robust and do, in fact, provide sufficient guidance in the vast majority of situations. Plant technical specifications, as well as many other NRC requirements and processes, provide a spectrum of conditions under which plant shutdown would be required. Plants have shut down numerous times in the past in accordance with NRC requirements. From time to time, however, a unique situation may present itself wherein sufficient information may not exist or the information available may not be sufficiently clear to apply existing rules and regulations definitively. In these unique instances, the NRC's most senior managers, after consultation with staff experts and given all of the information available at the time, will decide whether or not to require a plant shutdown. Risk information is used in accordance with RG 1.174. This process considers deterministic factors as well as probabilistic factors (i.e., risk information). We regard the combined use of deterministic and probabilistic factors to be a strength of our decisionmaking process.

See comment 13.

12. Page 38, third paragraph states: ***"At some point during this time, NRC staff also concluded that the first safety principle was probably not being met, although the basis for this conclusion is not known."***

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Response: The report should clarify GAO's basis for this statement. NRC staff believed that the regulations were met.

13. Page 40, last paragraph states: ***"However, NRC did not provide the assessment until a full year later—in December 2002. In addition, the December 2002 assessment, which includes a 4-page evaluation, does not fully explain how the safety principles were used or met—other than by stating that if the likelihood of nozzle failure were judged to be small, then adequate protection would be ensured."***

See comment 14.

Response: The attachment to the December 3, 2002, letter is an 8-page evaluation, not 4 pages. We note this to make sure GAO is referring to the same document. The assessment addresses four of the five safety principles. In the NRC's December 2002 safety evaluation, the staff stated that the criterion related to compliance with the regulations was being met because the inspections performed by the licensee were in conformance with the ASME Code. In addition, the safety evaluation stated that Davis-Besse met the criterion related to defense-in-depth because all three barriers against release of radiation were intact and reliable; they met the margin criterion because even the largest circumferential cracks found in pressurized-water reactors had considerable margin to structural failure, and they met the low-risk impact criterion based on a comparison of delta core damage frequency estimates with the guidelines of RG 1.174. The fifth safety principle, requiring a monitoring program, was not relevant to a decision that lasted only 6 weeks.

14. Page 42, first paragraph states: ***"Multiplying these two numbers, NRC estimated that the potential for a nozzle to crack and cause a loss-of-coolant accident would increase the frequency of core damage at Davis-Besse by about $5.4x10^5$ per year, or about 1 in 18,500 per year. Converting this frequency to a probability, NRC***

See comment 15.

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calculated that the increase in probability of core damage was approximately $5.0x10^{-6}$, or 1 chance in 200,000. While NRC officials currently disagree that this was the number it used, this is the number that it included in its December 2002 assessment provided to FirstEnergy. Further, we found no evidence in the agency's records to support NRC's current assertion."

Response: These statements mischaracterize the facts. NRC estimated that the probability of nozzle cracking leading to a loss-of-coolant accident during the first 6 weeks in 2002 would increase the annual core damage frequency (CDF) by about $5.4x10^{-6}$ per year, or about 1 in 185,000 per year. The estimate of $5x10^{-5}$ was an intermediate step in our calculation. The estimate of $5x10^{-5}$ represents the change in CDF if Davis-Besse were allowed to operate for one year without shutting down for inspection of the vessel head. Allowing Davis-Besse to continue to operate for one year was never a consideration. Thus, multiplying by the fraction of time in one year under consideration (in this case 7 weeks) was the final step in the calculation of delta CDF. The confusion about the estimate NRC used in the decisionmaking process may be due to NRC's method of calculating delta CDF for plant conditions which do not persist for the entire year. If this final step (the fraction of the year the plant is allowed to operate) were not part of the calculation, then the risk estimate of allowing the licensee to continue to operate for 7 weeks, as compared to one year, would be the same. Logically, this does not make sense. Therefore, the estimate of $5x10^{-5}$ does not automatically convert to a probability, as GAO's statement implies. Because the period of operation under consideration was approximately 0.13 years, the annual average change in CDF was about $5x10^{-6}$ per year, and the increase in the probability of core damage was about $5x10^{-6}$ as well. NRC officials **agree** that $5x10^{-6}$ was the estimate used in the decisionmaking process and is the estimate provided in the December 2002 assessment.

15. Page 42, second paragraph states: ***"For example, the consultants concluded that NRC's estimate of risk was incorrectly too small, primarily because the calculation did not consider corrosion of the vessel head."***

See comment 16.

Response: An underlying assumption in any risk assessment is that you have complete and accurate information from the licensee. NRC staff was of the understanding that efforts had been made to remove boric acid accumulation from the vessel head during previous outages. For all six B&W plants that found signs of penetration leakage, the leakage manifested itself in the form of small amounts of dry boron crystals on the vessel head, which are not corrosive, and did not produce any corrosion on the vessel heads of these six B&W plants. Boron leaking onto a clean vessel head does not cause corrosion. Therefore, corrosion this extensive was not anticipated at the time. Also, it is important to note that had Davis-Besse shut down on December 31, 2001, the same corrosion would have been found.

16. Page 43, first full paragraph discusses the experience at French nuclear power plants.

See comment 17.

Response: The NRC staff was aware of the issue as illustrated in an internal memorandum dated December 15, 1994, from Brian Grimes to Charles Rossi.

17. Page 44, first full paragraph states: ***"Third, NRC's analysis was inadequate because the risk estimates were higher than generally considered acceptable under NRC guidance. Despite PRA's [probabilistic risk assessment's] important role in the decision, our consultants found that NRC did not follow its guidance for ensuring that the estimated risk was within levels acceptable to the agency.*** Page 45, first paragraph states: ***"...NRC's PRA estimate for Davis-Besse resulted in an increase in the frequency of core damage of $5.4x10^{5}$ or 1 chance in about 18,500 per year was higher than the acceptable level."***

See comment 18.

Response: This conclusion is not supported by the facts and it is misleading. The estimate referenced by GAO is an intermediate calculation in our process, and was not used, and should not be used, in the decisionmaking process. NRC staff explained to the GAO consultants that NRC guidance produces an estimate for the change in core damage frequency of $5x10^{-6}$ per year, not $5x10^{-5}$ as indicated in the GAO report. According to RG 1.174, for Davis-Besse, this estimate is within acceptable bounds. NRC specifically documented the acceptability of the estimate in the December 2002 assessment. Thus, the December 3, 2002, safety evaluation concluded that the delta CDF was consistent with the guidelines of RG 1.174.

18. Page 45, first paragraph states: ***"NRC's guidance for evaluating requests to relax NRC technical specifications suggests that a probability increase higher than $5x10^{-7}$ or 1 chance in 2 million is considered unacceptable for relaxing the specifications. Thus, NRC's estimate would not be considered acceptable under this guidance."***

See comment 19.

Response: This criterion in RG 1.177 is not relevant to the Davis-Besse decision. It is confined to decisions on allowed outage times (AOT) for equipment, and is defined to avoid very high instantaneous risks (CDF > 10^{-3}) for very short periods (5 hours).

19. Page 46, first full paragraph states: ***"Lastly, NRC's analysis was inadequate because the agency does not have clear guidance for how PRA estimates are to be used in the decision-making process."***

See comment 20.

Response: The NRC's process for risk-informed decision-making is considerably more robust than characterized in this section. Regulatory Guide 1.174 comprises 40 pages of guidance on how to use risk in decisions of this type, and it is backed up by equally detailed guidance for specific types of decisions such as technical specifications, in-service inspection programs, in-service testing, and quality assurance. The NRC has

amassed a great deal of experience in application of the guidance. Risk assessment is a tool to help better inform decisions that are based on engineering judgements.

20. Page 46, last paragraph states: ***"It is not clear how NRC staff used the PRA risk estimate in the Davis-Besse decision-making process."***

See comment 21.

Response: The December 3, 2002, safety evaluation clearly states how the PRA estimate was used in the decisionmaking process; the estimate was compared with the guidelines of RG 1.174. The safety evaluation also points out that NRC staff who are expert in non-PRA disciplines such as probabilistic fracture mechanics, gave more weight to deterministic factors, such as the structural margin that remains in the nozzles with circumferential cracks. The NRC considers the combined use of deterministic and probabilistic factors to be a strength of our decisionmaking process.

21. Page 48, last paragraph states: ***"...NRC had made progress in implementing the recommendations, although some completion dates have slipped."***

See comment 22.

Response: The schedules for implementation of all high priority recommendations have not slipped. The implementation schedule for certain low or medium priority recommendations slip only in accordance with NRC's Planning, Budgeting and Performance Management (PBPM) process, which explicitly considers safety significance when making budget priority decisions.

22. Page 51, top of page, first full bullet states: ***"One recommendation is directed at improving NRC's generic communications program. NRC is..."***

See comment 23.

Response: We recommend re-wording this as follows: "One recommendation is directed at improving follow up of licensee actions taken in response to NRC generic communications. A Temporary Instruction (Inspection Procedure) is currently being

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developed to assess the effectiveness of licensee actions taken in response to generic communications. Additionally, improvements in the verification of effectiveness of generic communications are planned as a long-term change in the operating experience program."

23. Page 51, last paragraph states: ***"...NRC's revised inspection guidance for more thorough examinations of reactor vessel heads and nozzles, as well as new requirements for NRC oversight of licensees' corrective action programs, will require at least an additional 200 hours of inspection per reactor per year."***

See comment 24.

Response: It is unclear where this number comes from, but the changes to the corrective action program procedure require only about 16 hours per reactor year for the trend review.

24. Page 53, first paragraph discusses the NRC's Office of the Inspector General's (OIG's) findings on communications.

See comment 25.

Response: The NRC's actions are not limited primarily to improving communication about boric acid corrosion and cracking. There are multiple task force recommendations, and other NRC initiatives, that are aimed at addressing the broader implications stemming from communication lapses noted by the task force and the OIG. For example, actions have been implemented to more effectively disseminate operating experience to end users, reenforce a questioning attitude in the inspection staff, and discuss Davis-Besse lessons learned at various forums.

NRC's initial response to the OIG did not directly address the broader actions we are taking to improve communications. Our response to the OIG only indirectly addressed this by discussing the operating experience program enhancements. Part of the

enhancements to the operating experience program is the expectations for improved communications. In addition, communication improvement initiatives with internal and external stakeholders are in progress to address shortcomings in this critical area. Our revised response to the OIG on this issue, dated April 19, 2004, is provided as Enclosure 2.

25. Page 53, second paragraph states: ***"NRC's Davis-Besse task force did not make any recommendations to address two systemic problems: evaluating licensees' commitment to safety and improving the agency's process for deciding on a shutdown."***

See comment 26.

Response: The LLTF did not make a recommendation for improving the agency's process for deciding on a shutdown. This area was not reviewed in detail by the task force because of coordination with the OIG. Moreover, the task force review efforts were focused on why the degradation cavity was not prevented. While related, the shutdown issue had little to do with the degradation cavity.

See comment 5.

The task force made multiple recommendations aimed at enhancing NRC's capability to evaluate the licensees' commitment to safety, by indirect means. Refer to task force recommendations: 3.2.5(1), 3.2.5(2), 3.3.2(2), 3.3.4(5), and Appendix F.

26. Page 54, last paragraph states: ***"This problem identification and resolution inspection procedure is intended to assess the end-results of management's safety commitment rather than the commitment itself."***

See comment 5.

Response: This statement is inaccurate. Regarding its accuracy, the PI&R inspection procedure (IP 71152) actually has six stated inspection objectives (refer to section 71152-01) including: (1) provide for early warning of potential performance issues that could

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See comment 5.

result in crossing threshold in the action matrix and (2) to provide insights into whether licensees have established a safety-conscious work environment. Using this IP, inspectors seek factual evidence of the licensee's assumed commitment to safety (by reviewing their identification and correction of actual problems). Inspection issues routinely are raised with regard to a licensee's weakness in correcting recurrent problems or in adequately addressing issues that could become a future significant safety concern. The statement on Page 55 of the report, ***"Furthermore, because NRC directs its inspections at problems that it recognizes as being more important to safety, NRC may overlook other problems until they develop into significant and immediate safety problems"*** does not accurately reflect the stated objectives and demonstrable implementation of IP 71152.

27. Pages 55-56, discuss safety culture.

<u>Response</u>: To a significant degree, the areas referenced in this draft report are addressed either by NRC requirements or inspection activities. For example, the NRC has requirements limiting work hours for critical plant staff members such as security officers and plant operators. The NRC has requirements governing operator training. Inspectors routinely monitor various licensee meetings and job briefings to evaluate the licensee's emphasis on safety.

Moreover, the NRC has a number of other means to indirectly assess safety culture. Other NRC tools that provide indirect insights into licensee safety culture include:

- inspection procedure for assessing the licensee's employee concerns program,
- NRC's allegation program,
- enforcement of employee protection regulations,

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- Safety-Conscious Work Environment (SCWE) assessments during problem identification and resolution inspections,
- lessons-learned reviews such as the one conducted for the Davis-Besse reactor pressure vessel head degradation; and
- Reactor Oversight Process cross-cutting issues of human performance, problem identification and resolution, and SCWE.

See comment 27.

28. Page 58, paragraph under the first header states: ***"It recognized that NRC's written rationale for accepting FirstEnergy's justification for continued plant operation was not prepared until 1 year after its decision..."***

Response: For clarification, the documentation of the decision about one year later was corrective action from a task force finding.

See comment 28.

29. Page 58, paragraph under second header states: ***"The NRC task force did not address NRC's failure to learn from previous incidents at power plants and prevent their recurrence."***

Response: This sentence is factually inaccurate. The task force performed a limited review of past lessons-learned reports and actually identified many more potentially recurring programmatic issues as a result of that review than the three examples cited by the GAO in this section of the draft report. As discussed during the NRC-GAO exit conference, the task force made a recommendation to perform a more detailed effectiveness review of the actions stemming from other past NRC lessons learned reviews (Appendix F). This review is currently in progress.

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 19, 2004

MEMORANDUM TO: Hubert T. Bell
Inspector General

FROM: William D. Travers ***/RA Carl J. Paperiello Acting For/***
Executive Director for Operations

SUBJECT: FEBRUARY 2, 2004, OFFICE OF INSPECTOR GENERAL (OIG) MEMORANDUM CONCERNING AGENCY RESPONSE TO OIG EVENT INQUIRY CASE NO. 03-02S (NRC'S OVERSIGHT OF DAVIS-BESSE BORIC ACID LEAKAGE AND CORROSION DURING THE APRIL 2000 REFUELING OUTAGE)

This memorandum responds to your memorandum to Chairman Diaz, dated February 2, 2004, concerning the Nuclear Regulatory Commission (NRC) staff's response of January 12, 2004, to OIG Event Inquiry 03-02S. The referenced OIG event inquiry was initiated in response to a Congressional request that OIG determine how the NRC staff handled Davis-Besse Condition Report (CR) 2000-0782 at the time of discovery in refueling outage (RFO) 12 (2000) and whether the CR was considered in the November 2001 decision to allow Davis-Besse to continue to operate to February 16, 2002. The NRC staff's previous response to OIG (January 12, 2004) regarding this issue provided a matrix of those recommendations from the Davis-Besse Lessons Learned Task Force (DBLLTF) report that specifically addressed the event inquiry findings and referenced the report for a complete picture of the staff's efforts. The OIG response of February 2, 2004, stated that the NRC staff had not addressed the problem of communications as an underlying cause of the findings of the OIG event inquiry and that the agency should include an expectation of improved communication between and among NRC Headquarters and regional staff and should outline specific guidance to achieve this goal. In addition, OIG specifically concluded that "had the [Davis-Besse Nuclear Power Station] DBNPS inspectors been better informed of ongoing NRC industry-wide efforts to address coolant pressure boundary leakage and the effects of boric acid corrosion, they would have recognized the significance of Condition Report 2000-0782 and highlighted the information to regional management."

The DBLLTF report discusses the NRC's and industry's failure to understand the significance of boric acid corrosion of the reactor vessel head. The NRC staff believes that this failure caused the underlying communications lapses. Although the potential for this type of degradation existed previously, the significance of boric acid deposits was not understood by the staff. The assumption throughout NRC was that the boric acid deposits would be in a dry, powder-like form that could easily be removed and would not accumulate in a condition that would be corrosive to the reactor vessel head. As identified in the event inquiry, the inspectors did communicate a substantial amount of information to the region and the NRR Project Manager, particularly regarding the fouling of the containment air coolers and radiation monitor filter

Contact: Edwin M. Hackett, NRR/DLPM/PDII
415-1485

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elements; however, the significance of this information was also not appreciated at the time. This same failure to understand the significance of the situation was the cause of the lack of communication from Headquarters to the regions. Several elements of the matrixed DBLLTF Action Plans address this underlying issue of lack of recognition of the significance of the evidence. The desired outcome for these actions is for all NRC staff to maintain a questioning attitude and lower thresholds for communications concerning materials degradation corrosion.

More broadly, the NRC staff agrees that communications are of critical importance in all aspects of NRC activities and particularly important as an underlying cause for issues discovered at DBNPS. The corrective actions outlined in the DBLLTF Action Plans address communications beyond the topic of boric acid corrosion control. For example, corrective actions in the area of operating experience development and use are focused on enhancing communications. The recommendations to strengthen inspection guidance, institute training to reinforce a questioning attitude on the part of management and staff, and change the Inspection Manual to provide guidance for the staff to pursue issues identified during plant status reviews are intended to establish more definitive expectations for improved communications of operating experience. As discussed in the February 23, 2004, semiannual update report and at the February 26, 2004, Commission meeting, implementation plans for this area are still under development and may significantly influence the way the agency does business in the future. Developing the most effective and efficient communications channels will be key to the successful implementation of an effective operating experience program.

Beyond the DBLLTF Action Plan, the agency has several ongoing initiatives that provide examples of efforts to more broadly improve intra-agency communications. These examples include establishment of a Communication Council reporting to the Executive Director for Operations and the creation of a communications specialist position reporting to the Office of Nuclear Reactor Regulation (NRR) Associate Director for Inspections and Programs. NRR also continues to improve and enhance its Web site as a focused means of communicating with both internal and external stakeholders. From a regional perspective, examples of communication enhancements include lowering the threshold for communication of plant issues on morning status calls, devoting additional time to discussing lessons learned from plant events and inspection findings during counterpart meetings, and developing enhanced guidance for documenting significant operational event followup decisions. Collectively, these examples provide a strong indication that NRC Headquarters and regional staff have begun to internalize two of the most important lessons from the Davis-Besse event. These are that on occasion, information initially considered to have low significance by the first NRC recipient is later found to be of greater significance once the information is shared and evaluated more collegially; and with regard to the complex nature of commercial nuclear power operations, no one person can be aware of all aspects of an issue. As a result, the more information that is shared, the more likely significant problems will be identified and appropriate action(s) taken.

In summary, the NRC staff recognizes that communication failures were an underlying cause of the agency's problems concerning the delayed discovery of the boric acid corrosion at DBNPS. Our January 12, 2004, response to the event inquiry specifically addressed what we considered to be the root cause of the event-specific communication failures, namely that the entire staff did not recognize the potential significance of boric acid corrosion. Expectations for improved communications will be developed as an integral part of our operating experience program enhancements. More broadly, communication improvement initiatives with internal and external

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stakeholders are in progress to enhance agency performance in this critical area of our responsibilities. We regret that our initial response did not clearly address the broader actions we are taking to improve communications and appreciate the opportunity to clarify our response.

cc: Chairman Diaz
Commissioner McGaffigan
Commissioner Merrifield
SECY
LReyes

The following are GAO's comments on the Nuclear Regulatory Commission's letter dated May 5, 2004.

GAO Comments

1. We agree with NRC that 10 C.F.R. § 50.9 requires that information provided to NRC by a licensee be complete and accurate in all material respects, and we have added this information to the report. NRC also states that in carrying out its oversight responsibilities, NRC must "rely heavily" on licensees providing accurate information. However, we believe that NRC's oversight program should not place undue reliance on applicants providing complete and accurate information. NRC also recognizes that it cannot rely solely on information from licensees, as evidenced by its inspection program and process for determining the significance of licensee violations. Under this process, NRC considers whether there are any willful aspects associated with the violation—including the deliberate intent to violate a license requirement or regulation or falsify information. We believe that management controls, including inspection and enforcement, should be implemented by NRC so as to verify whether licensee-submitted information considered to be important for ensuring safety is complete and accurate as required by the regulation. In this regard, as stated in NRC's enforcement policy guidance, NRC is authorized to conduct inspections and investigations (Atomic Energy Act § 161); revoke licenses for, among other things, a licensee's making material false statements or failing to build or operate a facility in accordance with the terms of the license (Atomic Energy Act § 186); and impose civil penalties for a licensee's knowing failure to provide certain safety information to NRC (Energy Reorganization Act § 206).

   With regard to the draft report conveying the expectation that NRC should have known about the thick layer of boron on the reactor vessel head, we note in the draft report that since at least 1998, NRC was aware that (1) FirstEnergy's boric acid corrosion control program was inadequate, (2) radiation monitors within the containment area were continuously being clogged by boric acid deposits, (3) the containment air cooling system had to be cleaned repeatedly because of boric acid buildup, (4) corrosion was occurring within containment as evidenced by rust particles being found, and (5) the unidentified leakage rate had increased above the level that historically had been found at the plant. NRC was also aware of the repeated but ineffective attempts by FirstEnergy to correct many of these recurring problems—evidence that the licensee's programs to identify and correct problems were not

effective. Given these indications at Davis-Besse, NRC could have taken more aggressive follow-up action to determine the underlying causes. For example, NRC could have taken action during the fuel outage in 1998, the shutdown to repair valves in mid-1999, or the fuel outage in 2000 to ensure that staff with sufficient knowledge appropriately investigated the types of conditions that could cause these indications, or followed up to ensure that FirstEnergy had fully investigated and successfully resolved the cause of the indications.

2. With respect to the responsibility of the licensee to provide complete and accurate information, see comment 1. As to the Davis-Besse lessons-learned task force finding, we agree that some information provided by FirstEnergy in response to Bulletin 2001-01 may have been inconsistent with some information subsequently identified by NRC's lessons-learned task force, and that had some of this information been known in the fall of 2001, the vessel head leakage and degradation may have been identified sooner than March 2002. This information included (1) the boric acid accumulations found on the vessel head by FirstEnergy in 1998 and 2000, (2) FirstEnergy's limited ability to visually inspect the vessel head, (3) FirstEnergy's boric acid corrosion control procedures relative to the vessel head, (4) FirstEnergy's program to address the corrosive effects of small amounts of reactor coolant leakage, (5) previous nozzle inspection results, (6) the bases for FirstEnergy's conclusion that another source of leakage—control rod drive mechanism flanges—was the source of boric acid deposits on the vessel head that obscured multiple nozzles, and (7) photographs of vessel head penetration nozzles. However, various NRC officials knew some of this information, other information should have been known by NRC, and the remaining information could have been obtained had NRC requested it from FirstEnergy. For example, according to the senior resident inspector, he reviewed every Davis-Besse condition report on a daily basis to determine whether the licensee properly categorized the safety significance of the conditions. Vessel head conditions found by FirstEnergy in 1998 and 2000 were noted in such condition reports or in potential-condition-adverse-to-quality reports. According to a FirstEnergy official, photographs of the pressure vessel head nozzles were specifically provided to NRC's resident inspector, who, although he did not specifically recall seeing the photographs, stated that he had no reason to doubt the FirstEnergy official's statement. NRC had been aware, in 1999, of limitations in FirstEnergy's boric acid corrosion control program and, while it cited FirstEnergy for its failure to adequately implement the program, NRC officials did not

follow up to determine if the program had improved. Lastly, while NRC questioned the information provided by FirstEnergy in its submissions to NRC in response to Bulletin 2001-01 (regarding vessel head penetration nozzle inspections), NRC staff did not independently review and assess information pertaining to the results of past reactor pressure vessel head inspections and vessel head penetration nozzle inspections. Similarly, NRC did not independently assess the information concerning the extent and nature of the boric acid accumulations found on the vessel head by the licensee during past inspections.

On page 2 of the report, we note that the Department of Justice has an ongoing investigation concerning the completeness and accuracy of information that FirstEnergy provided to NRC on the conditions at Davis-Besse. The investigation may or may not find that FirstEnergy provided inaccurate or incomplete information. While NRC notes that it might have detected something months earlier if information had been known in the fall of 2001, we would also note that the degradation of the reactor vessel head likely took years to occur.

3. We believe that the statement is correct. NRC produced an estimate of 5×10^{-5} per year for the change in core damage frequency, as we state in the report. NRC specifically documented this calculation in its December 2002 assessment:

"The NRC staff estimated that, giving credit only to the [FirstEnergy] inspection performed in 1996, the probability of a [control rod drive mechanism] nozzle ejection during the period of operation from December 31, 2001, to February 16, 2002, was in the range of 2E-3 and was an increase in the overall [loss of coolant accident] probability for the plant. The increase in core damage probability and large early release probability were estimated as approximately 5E-6 and 5E-08, respectively."[1]

The probability of a large early release—5E-6—equates to a frequency of 5×10^{-5} per year.[2] As we note in the report, according to NRC's

[1]The numbers 2E-3, 5E-6, and 5E-8 can also be written as 2×10^{-3}, 5×10^{-6}, and 5×10^{-8}.

[2]The probability of an event occurring is the product of the frequency of an event and a given time period. In this case, the time period—7 weeks—was approximated as one-tenth of the year. Thus, 5.4×10^{-5} per year multiplied by 0.10 equates to a probability of 5.4×10^{-6}. According to NRC, it revised 5.4×10^{-6} to 5.0×10^{-6} to account for uncertainties.

regulatory guide 1.174, this frequency would be in the highest risk zone and NRC would generally not approve the requested change.

On several occasions, we met with the NRC staff that developed the risk estimate in an attempt to understand how it was calculated. We obtained from NRC staff the risk estimate information provided to senior management in late November 2001, as well as several explanations of how the staff developed its calculations. We were provided with no evidence that NRC estimated the frequency of core damage as being 5×10^{-6} per year until February 2004, after our consultants and we had challenged NRC's estimate as being in the highest risk zone under NRC's regulatory guide 1.174. Furthermore, several NRC staff involved in deciding whether to issue the order to shut down Davis-Besse, or to allow it to continue operating until February 16, 2002, stated that the risk estimate they used was relatively high.

4. We agree that existing regulations provide a spectrum of conditions under which a plant shutdown could occur and that could be interpreted as covering the vast majority of situations. However, we continue to believe that NRC lacks sufficient guidance for making plant shutdown decisions. We disagree on two grounds: First, the decision-making guidance used by NRC to shut down Davis-Besse was guidance for approving license change requests. This guidance provides general direction on how to make risk-informed decisions when licensees request license changes. It does not address important aspects of decision-making involved in deciding whether to shut down a plant. It also does not provide direction on how NRC should weigh deterministic factors in relation to probabilistic factors in making shutdown decisions. Secondly, while NRC views the flexibility afforded by its existing array of guidance as a strength, we are concerned that, even on the basis of the same information or circumstances, staff can arrive at very different decisions. Without more specific guidance, NRC will continue to lack accountability and the degree of credibility needed to convince the industry and the public that its shutdown decisions are sufficiently sound and reasoned for protecting public health and safety.

5. We are aware that the commissioners have specifically decided not to conduct direct evaluations or inspections of safety culture. We agree that as regulators, NRC is not charged with managing licensees' facilities, but disagree that any direct NRC involvement with safety culture crosses over to a management function. Management is an

embodiment of corporate beliefs and perceptions that affect management strategies, goals, and philosophies. These, in turn, impact licensee programs and processes and employee behaviors that have safety outcomes. We believe that NRC should not assess corporate beliefs and perceptions or management strategies, goals, or philosophies. Rather, we believe that NRC has a responsibility to assess licensee programs and processes, as well as employee behaviors. We cite several areas of safety culture in the report as being examples of various aspects of safety culture that NRC can assess which do not constitute "management functions." The International Atomic Energy Agency has extensive guidance on assessing additional aspects of licensee performance and indicators of safety culture.[3] Such assessments can provide early indications of declining safety culture prior to when negative safety outcomes occur, such as at Davis-Besse.

We also agree that NRC has indirect means by which it attempts to assess safety culture. For example, NRC's problem identification and resolution inspection procedure's stated objective is to provide an early warning of potential performance issues and insight into whether licensees have established safety conscious work environments. However, we do not believe that the implementation of the inspection procedure has been demonstrated to be effective in meeting its stated objectives. The inspection procedure directs inspectors to screen and analyze trends in all reported power plant issues. In doing so, the procedure directs that inspectors annually review 3 to 6 issues out of potentially thousands of issues that can arise and that are related to various structures, systems, and components necessary for the safe operation of the plant. This requires that inspectors judgmentally sample 3 to 6 issues on which they will focus their inspection resources. While we do not necessarily question inspector judgment when sampling for these 3 to 6 issues, NRC inspectors stated that due to the large number of issues that they can sample from, they try to focus on those issues that they believe have the most relevance for safety. Thus, if an issue is not yet perceived as being important to safety, it is less likely to be selected for follow up. Further, even if an issue were selected for follow up and this indicated that the licensee did not properly identify and resolve underlying problems that contributed to the issue, according to NRC officials, it is highly unlikely

[3]The International Atomic Energy Agency, International Nuclear Safety Advisory Group, *Safety Culture* (Vienna, Austria: February 1991).

that this one issue would rise to a high enough level of significance for it to be noted under NRC's Reactor Oversight Process. Additionally, the procedure is dependant on the inspector being aware of, and having the capability to, identify issues or trends in the area of safety culture. According to NRC officials, inspectors are not trained in what to look for when assessing licensee safety culture because they are, by and large, nuclear engineers. While they may have an intuition that something is wrong, they may not know how to assess it in terms of safety culture.

Additional specific examples NRC cites for indirectly assessing a selected number of safety culture aspects have the following limitations:

- NRC's inspection procedure for assessing licensees' employee concerns program is not frequently used. According to NRC Region III officials, approval to conduct such an inspection must be given by the regional administrator and the justification for the inspection to be performed has to be based on a very high level of evidence that a problem exists. Because of this, these officials said that the inspection procedure has only been implemented twice in Region III.

- NRC's allegation program provides a way for individuals working at NRC-regulated plants and the public to provide safety and regulatory concerns directly to NRC. It is a reactive program by nature because it is dependent upon licensees' employees feeling free and able to come forward to NRC with information about potential licensee misconduct. While NRC follows up on those plants that have a much higher number of allegations than other plants to determine what actions licensees are taking to address any trends in the nature of the allegations, the number of allegations may not always provide an indication of a poor safety culture, and in fact, may be the reverse. For example, the number of allegations at Davis-Besse prior to the discovery of the cavity in the reactor head in March 2002 was relatively small. Between 1997 and 2001, NRC received 10 allegations from individuals at the plant. In contrast, NRC received an average of 31 allegations per plant over the same 5-year period from individuals at other plants.

- NRC's lessons-learned reviews, such as the one conducted for Davis-Besse, are generally conducted when an incident having potentially serious safety consequences has already occurred.

- With respect to NRC's enforcement of employee protection regulations, NRC, under its current enforcement policy, would normally only take enforcement action when violations are of very significant or significant regulatory concern. This regulatory concern pertains to NRC's primary responsibility for ensuring safety and safeguards and protecting the environment. Examples of such violations would include the failure of a system designed to prevent a serious safety incident not working when it is needed, a licensed operator being inebriated while at the control of a nuclear reactor, and the failure to obtain prior NRC approval for a license change that has implications for safety. If violations of employee protection regulations do not pose very significant or significant safety, safeguards, or environmental concerns, NRC may consider such violations minor. In such cases, NRC would not normally document such violations in inspection reports or records, and would not take enforcement action.

- NRC's Reactor Oversight Process, instituted in April 2000, focuses on seven specific "cornerstones" that support the safety of plant operations to ensure reactor safety, radiation safety, and security. These cornerstones are: (1) the occurrence of operations and events that could lead to a possible accident if safety systems did not work, (2) the ability of safety systems to function as intended, (3) the integrity of the three safety barriers, (4) the effectiveness of emergency preparedness, (5) the effectiveness of occupational radiation safety, (6) the ability to protect the public from radioactive releases, and (7) the ability to physically protect the plant. NRC's process also includes three elements that cut across these seven cornerstones: (1) human performance, (2) a licensee's safety-conscious work environment, and (3) problem identification and resolution. NRC assumes that problems in any of these three crosscutting areas will be evidenced in one or more of the seven cornerstones in advance of any serious compromise in the safety of a plant. However, as evidenced by the Davis-Besse incident, this assumption has not proved to be true.

NRC also cites lessons-learned task force recommendations to improve NRC's ability to detect problems in licensee's safety culture, as a means to achieve our recommendation to directly assess licensee safety culture. These lessons-learned task force recommendations include (1) developing inspection guidance to assess the effect that a licensee's fuel outage shutdown schedule has on the scope of work conducted

during a shutdown; (2) revising inspection guidance to provide for assessing the safety implications of long-standing, unresolved problems; corrective actions being phased in over the course of several years or refueling outages; and deferred plant modifications; (3) revising the problem identification and resolution inspection approach and guidance; and (4) reviewing the range of NRC's inspections and assessment processes and other NRC programs to determine whether they are sufficient to identify and dispose of the types of problems experienced at Davis-Besse. While we commend these recommendations, we do not believe that revising such guidance will necessarily alert NRC inspectors to early declines in licensee safety culture before they result in negative safety outcomes. Further, because of the nature of NRC's process for determining the relative safety significance of violations under NRC's new Reactor Oversight Process, we do not believe that any indications of such declines will result in a cited violation.

6. We have revised the report to reflect that boron in the form of boric acid crystals is dissolved in the cooling water. (See p. 13.)

7. On page 41 of the report, we recognize that NRC also relied on information provided by FirstEnergy regarding the condition of the vessel head. For example, in developing its risk estimate, NRC credited FirstEnergy with a vessel head inspection conducted in 1996. However, NRC decided that the information provided by FirstEnergy documenting vessel head inspections in 1998 and 2000 was of such poor quality that it did not credit FirstEnergy with having conducted them. As a result, NRC's risk estimate was higher than had these inspections been given credit.

8. The statement made by the NRC regional branch chief was taken directly from NRC's Office of the Inspector General report on NRC's oversight of Davis-Besse during the April 2000 refueling outage.[4]

9. We agree that up until the Davis-Besse event, NRC had not concluded that boric acid corrosion was a high priority issue. We clarified the text of the report to reflect this comment. (See p. 25.)

[4]NRC, Office of the Inspector General, *NRC's Oversight of Davis-Besse during the April 2000 Refueling Outage* (Washington, D.C.: Oct. 17, 2003).

10. We agree that plant operators in France decided to replace their vessel heads in lieu of performing the extensive inspections instituted by the French regulatory authority. The report has been revised to add these details. (See p. 31.)

11. We agree that caked-on boron, in combination with leakage, could accelerate corrosion rates under certain conditions. However, even without caked-on boron, corrosion rates could be quite high. Westinghouse's 1987 report on the corrosive effects of boric acid leakage concluded that the general corrosion rate of carbon steel can be unacceptably high under conditions that can prevail when primary coolant leaks onto surfaces and concentrates at the temperatures that are found on reactor surfaces. In one series of tests that it performed, boric acid solutions corroded carbon steel at a rate of about 0.4 inches per month, or about 4.8 inches a year. This was irrespective of any caked-on boron. In 1987, as a result of that report and extensive boric acid corrosion found at two other nuclear reactors that year—Salem unit 2 and San Onofre unit 2—NRC concluded that a review of existing inspection programs may be warranted to ensure that adequate monitoring procedures are in place to detect boric acid leakage and corrosion before it can result in significant degradation of the reactor coolant pressure boundary. However, NRC did not take any additional action.

12. We agree that NRC has requirements and processes that provide a number of circumstances in which a plant shutdown would or could be required. We also recognize that there were no legal objections to the draft enforcement order to shut down the plant, and that the basis for not issuing the order was NRC's belief that the plant did not pose an unacceptable risk to public health and safety. The statement in our report that NRC is referring to is discussing one of these circumstances—the licensee's failure to meet NRC's technical specification—and whether NRC believed that it had enough proof that the technical specification was not being met. The statement is not discussing the basis for NRC issuing an enforcement order. We revised the report to clarify this point. (See p. 34.)

13. The basis for our statement that NRC staff concluded that the first safety principle was probably not met was its November 29, 2001, briefing to NRC's Executive Director's Office and its November 30, 2001, briefing to the NRC commissioners' technical assistants. These briefings, the basis for which are included in documented briefing

slides, took place shortly before NRC formally notified FirstEnergy on December 4, 2001, that it would accept its compromise shutdown date.

14. We are referring to the same document that NRC is referring to—NRC's December 3, 2002, response to FirstEnergy (NRC's ADAMS accession number ML023300539). The response consists of a 2-page transmittal letter and an 7.3-page enclosure. The 7.3-page enclosure is 3 pages of background and 4.3 pages of the agency's assessment. The assessment includes statements that the safety principles were met but does not provide an explanation of how NRC considered or weighed deterministic and probabilistic information in concluding that each of the safety factors were met. For example, NRC concluded that the likelihood of a loss-of-coolant accident was acceptably small because of the (1) staff's preliminary technical assessment for control rod drive mechanism cracking, (2) evidence of cracking found at other plants similar to Davis-Besse, (3) analytical work performed by NRC's research staff in support of the effort, and (4) information provided by FirstEnergy regarding past inspections at Davis-Besse. However, the assessment does not explain how these four pieces of information successfully demonstrated if and how each of the safety principles was met. The assessment also states that NRC examined the five safety principles, the fifth of which is the ability to monitor the effects of a risk-informed decision. The assessment is silent on whether this principle is met. However, in NRC's November 29, 2001, briefing to NRC's Executive Director's Office and in its November 30, 2001, briefing to the NRC commissioners' technical assistants, NRC concluded that this safety principle was not met. As noted above, NRC formally notified FirstEnergy on December 4, 2001, that it would accept FirstEnergy's February 16, 2002, shutdown date.

15. See comment 3. We do not agree that the report statements mischaracterize the facts. Rather, we are concerned that NRC is misusing basic quantitative mathematics. In addition, with regard to NRC's concept of an annual average change in the frequency of core damage, NRC stated that the agency averaged the frequency of core damage that would exist for the 7-week period of time (representing the period of time between December 31, 2001, and February 16, 2002) over the entire 1-year period, using the assumption that the frequency of core damage would be zero for the remainder of the year—February 17, 2002, to December 31, 2002. According to our consultants, this calculation *artificially* reduced NRC's risk estimate to a level that is acceptable under NRC's guidance. By this logic, our consultants stated,

risks can always be reduced by spreading them over time; by assuming another 10 years of plant operation (or even longer) NRC could find that its calculated "risks" are completely negligible. They further stated that NRC's approach is akin to arguing that an individual, who drives 100 miles per hour 10 percent of the time, with his car otherwise garaged, should not be cited because his time-average speed is only 10 miles per hour.

Further, our consultants concluded that the "annual-average" core damage frequency approach was also clearly unnecessary, since one need only convert a core damage frequency to a core damage probability to handle part-year cases like the Davis-Besse case. Lastly, we find no basis for the calculation in any NRC guidance. According to our consultants, this new interpretation of NRC's guidance is at best unusual and certainly is inconsistent with NRC's guidelines regarding the use of an incremental core damage frequency. This interpretation also reinforces our consultants' impression that perhaps there was, in November 2001 and possibly is still today, some confusion among the NRC staff regarding basic quantitative metrics that should be considered in evaluating regulatory and safety issues. As noted in comment 3, we found no evidence of this calculation prior to February 2004.

16. While we agree that vessel head corrosion as extensive as later found at Davis-Besse was not anticipated, NRC had known that leakage of the primary coolant from a through-wall crack could cause boric acid corrosion of the vessel head, as evidenced by the Westinghouse work cited above. Regardless of information provided to NRC by individual licensees, such as FirstEnergy, NRC's model should account for known risks, including the potential for corrosion.

17. We agree that NRC was aware of control rod drive mechanism nozzle cracking at French nuclear power plants. NRC provided us additional information consisting of a December 15, 1994, internal memo, in which NRC concluded that primary coolant leakage from a through-wall crack could cause boric acid corrosion of the vessel head. However, because some analyses indicated that it would take at least 6 to 9 years before any corrosion would challenge the structural integrity of the head, NRC concluded that cracking was not a short-term safety issue. We revised the report to include this additional information. (See p. 40.)

18. See comment 15.

19. We agree that while not directly relevant to the Davis-Besse situation, NRC uses regulatory guide 1.177 to make decisions on whether certain equipment can be inoperable while a nuclear reactor is operating, which can pose very high instantaneous risks for very short periods of time. However, we include the reference to this particular guidance in the report because it was cited by an NRC official involved in the Davis-Besse decision-making process as another piece of guidance used in judging whether the risk that Davis-Besse posed was acceptable.

20. While regulatory guide 1.174 comprises 25 pages of guidance on how to use risk in making decisions on whether to allow license changes, it does not lay out how NRC staff are to use quantitative estimates of risk or probabilistic factors, or how robust these estimates must be in order to be considered along with more deterministic factors. The regulatory guide, which was first issued in mid-1998, had been in effect for only about 1.5 years when NRC staff was tasked with making their decision on Davis-Besse. According to the Deputy Executive Director of Nuclear Reactor Programs at the time the decision was being made, the agency was trying to bring the staff through the risk-informed decision-making process because Davis-Besse was a learning tool. He further stated that it was really the first time the agency had used the risk-informed decision-making process on operational decisions as opposed to programmatic decisions for licensing. At the time the decision was made, and currently, NRC has no guidance or criteria for use in assessing the quality of risk estimates or clear guidance or criteria for how risk estimates are to be weighed against other risk factors.

21. The December 3, 2002, safety assessment or evaluation did state that the estimated increase in core damage frequency was consistent with NRC's regulatory guidelines. However, as noted in comment 3, we disagree with this conclusion. In addition, while we agree that NRC has staff with risk assessment disciplines, we found no reference to these staff in NRC's safety evaluation. We also found no reference to NRC's statement that these staff gave more weight to deterministic factors in arriving at the agency's decision. While we endorse NRC's consideration of deterministic as well as probabilistic factors and the use of a risk-informed decision-making process, we continue to maintain that NRC needs clear guidance and criteria for the quality of risk estimates, standards of evidence, and how to apply deterministic as well as probabilistic factors in plant shutdown decisions. As the agency continues to incorporate a risk-informed process into much of its regulatory guidance and programs, such criteria will be increasingly

important when making shutdown as well as other types of decisions regarding nuclear power plants.

22. The information that NRC provided us indicates that completion dates for 2 of the 22 high priority recommendations have slipped.[5] One, the completion date for encouraging the American Society of Mechanical Engineers to revise vessel head penetration nozzle inspection requirements or, alternatively, for revising NRC's regulations for vessel head inspections has slipped from June 2004 to June 2006. Two, the completion date for assessing NRC's requirements that licensees have procedures for responding to plant leakage alarms to determine if the requirements are sufficient for identifying reactor coolant pressure boundary leakage has slipped from March 2004 to March 2005.

23. We agree with this comment and have revised the report to reflect this clarification. (See p. 49.)

24. Our estimate of at least an additional 200 hours of inspection per reactor per year is based on:

   - NRC's new requirement that its resident inspectors review all licensee corrective action items on a daily basis (approximately 30 minutes per day). Given that reactors are intended to operate continuously throughout the year, this results in about 3.5 hours per week for reviewing corrective action items, or about 182 hours per year. In addition, resident inspections are now required to determine, on a semi-annual basis, whether such corrective action items reflect any trends in licensee performance (16 to 24 hours per year). The total increase for these new requirements is about 198 to 206 hours per reactor per year.

   - A new NRC requirement that its resident inspectors validate that licensees comply with additional inspection commitments made in response to NRC's 2002 generic bulletin regarding reactor pressure vessel head and vessel head penetration nozzles. This requirement results in an additional 15 to 50 hours per reactor per fuel outage.

[5]Of NRC's 21 high priority recommendations, we categorized 1 recommendation as 2 so that we could better track actions taken to implement it. Thus, we have 22 recommendations categorized as high priority.

25. Our draft report included a discussion that NRC management's failure to recognize the scope or breadth of actions and resources necessary to fully implement task force recommendations could adversely affect how effective the actions may be. We made this statement based on NRC's initial response to the Office of the Inspector General's October 2003 report on Davis-Besse.[6] That report concluded that ineffective communication within NRC's Region III and between Region III and NRC headquarters contributed to the Davis-Besse incident. NRC, in its January 2004 response to the report, stated that among other things, it had developed training on boric acid corrosion and revised its inspection program to require semi-annual trend reviews. In February 2004, the Office of the Inspector General criticized NRC for limiting the agency's efforts in responding to its findings. Specifically, it stated that NRC did not address underlying and generic communication failures identified in the Office's report. In response to the criticism, on April 19, 2004 (while our draft report was with NRC for review and comment), NRC provided the Office of the Inspector General with additional information to demonstrate that its actions to improve communication within the agency were broader than indicated in the agency's January 2004 response. Based on NRC's April 19, 2004, response and the Office's agreement that NRC's actions appropriately address its concerns about communication within the agency, we deleted this discussion in the report.

26. We recognize that the lessons-learned task force did not make a recommendation for improving the agency's decision-making process because the task force coordinated with the Office of the Inspector General regarding the scope of their respective review activities and because the task force was primarily charged with determining why the vessel head degradation was not prevented. (See p. 55.)

27. We agree that NRC's December 3, 2002, documentation of its decision was prepared in response to a finding by the Davis-Besse lessons-learned task force. We revised our report to incorporate this fact. (See p. 55.)

28. We agree that NRC's lessons-learned task force conducted a preliminary review of reports from previous lessons-learned task forces

[6]NRC, Office of the Inspector General, *NRC's Oversight of Davis-Besse during the 2000 Refueling Outage* (Washington, D.C.: Oct. 17, 2003).

and, as a result of that review, made a recommendation that the agency perform a more detailed effectiveness review of the actions taken in response to those reviews. We revised the report to reflect that NRC's detailed review is currently underway. (See p. 55.)

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Staff Acknowledgments

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Related GAO Products

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United States Government Accountability Office

GAO

Report to Congressional Requesters

April 2005

NUCLEAR REGULATORY COMMISSION

NRC Needs to Do More to Ensure that Power Plants Are Effectively Controlling Spent Nuclear Fuel

GAO

Accountability * Integrity * Reliability

GAO-05-339

April 2005

GAO
Accountability · Integrity · Reliability

Highlights

Highlights of GAO-05-339, a report to congressional requesters

Why GAO Did This Study

Spent nuclear fuel—the used fuel periodically removed from reactors in nuclear power plants—is too inefficient to power a nuclear reaction, but is intensely radioactive and continues to generate heat for thousands of years. Potential health and safety implications make the control of spent nuclear fuel of great importance. The discovery, in 2004, that spent fuel rods were missing at the Vermont Yankee plant in Vermont generated public concern and questions about the Nuclear Regulatory Commission's (NRC) regulation and oversight of this material.

GAO reviewed (1) plants' performance in controlling and accounting for their spent nuclear fuel, (2) the effectiveness of NRC's regulations and oversight of the plants' performance, and (3) NRC's actions to respond to plants' problems controlling their spent fuel.

What GAO Recommends

GAO recommends that NRC (1) establish specific requirements for the control and accounting of loose rods and fragments and plants' conduct of their physical inventories and (2) develop and implement appropriate inspection procedures to verify plants' compliance with the requirements.

Commenting on the draft report, NRC generally agreed with GAO's conclusions and recommendations.

www.gao.gov/cgi-bin/getrpt?GAO-05-339.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells at (202) 512-3841 or wellsj@gao.gov.

NUCLEAR REGULATORY COMMISSION

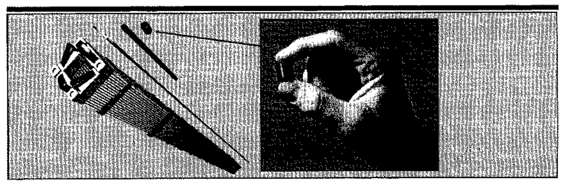
NRC Needs to Do More to Ensure that Power Plants Are Effectively Controlling Spent Nuclear Fuel

What GAO Found

Nuclear power plants' performance in controlling and accounting for their spent fuel has been uneven. Most recently, three plants—Vermont Yankee and Humboldt Bay (California) in 2004 and Millstone (Connecticut) in 2000—have reported missing spent fuel. Earlier, several other plants also had missing or unaccounted for spent fuel rods or rod fragments.

NRC regulations require plants to maintain accurate records of their spent nuclear fuel and to conduct a physical inventory of the material at least once a year. The regulations, however, do not specify how physical inventories are to be done. As a result, plants differ in the regulations' implementation. For example, physical inventories at plants varied from a comprehensive verification of the spent fuel to an office review of the records and paperwork for consistency. Additionally, NRC regulations do not specify how individual fuel rods or segments are to be tracked. As a result, plants employ various methods for storing and accounting for this material. Further, NRC stopped inspecting plants' material control and accounting programs in 1988. According to NRC officials, there was no indication that inspections of these programs were needed until the event at Millstone.

NRC is collecting information on plants' spent fuel programs to decide if it needs to revise its regulations and/or oversight. In addition to reviewing specific instances of missing fuel, NRC has had its inspectors collect basic information on all facilities' programs. It has also contracted with the Department of Energy's Oak Ridge National Laboratory in Tennessee to review NRC's material control and accounting programs for nuclear material, including spent fuel. It further plans to request information from plant sites and visit over a dozen of them for more detailed inspection. These more detailed inspections may not be completed until late 2005, over 5 years after the instance at Millstone that initiated NRC's efforts. However, we believe NRC has already collected considerable information indicating problems or weaknesses in plants' material control and accounting programs for spent fuel.



Source: Nuclear Energy Institute.

Nuclear fuel rods are filled with ceramic pellets of uranium and grouped into fuel assemblies, typically 5 to 10 inches square and 12 to 14 feet long.

Contents

Abbreviations

DOE	Department of Energy
ISFSI	independent spent fuel storage installation
NRC	Nuclear Regulatory Commission
OIG	Office of the Inspector General
TI	temporary instruction

United States Government Accountability Office
Washington, D.C. 20548

April 8, 2005

The Honorable James M. Jeffords
Ranking Minority Member
Committee on Environment and Public Works
United States Senate

The Honorable Patrick Leahy
United States Senate

The Honorable Bernie Sanders
House of Representatives

The Honorable John Olver
House of Representatives

Spent nuclear fuel—the used fuel periodically removed from reactors in nuclear power plants—is one of the most hazardous materials made by humans. Without protective shielding, the fuel's intense radiation can kill a person within minutes if directly exposed to it or cause cancer in those exposed to smaller doses. The nation's 103 operating nuclear power plants, which generate about 20 percent of U.S. electricity, annually produce over 2,000 metric tons of spent fuel. Absent a national repository, these materials must be stored on site. Given the potential harm to human health and the environment, the Nuclear Regulatory Commission (NRC) requires licensees or operators of commercial nuclear power plants to strictly control and account for their spent fuel. However, several recent discoveries of missing or unaccounted-for spent fuel have raised concerns about nuclear power plants' control over these materials and NRC's oversight. The terrorist attacks of September 11, 2001, heightened these concerns by raising questions about whether these highly radioactive materials could be diverted or stolen and used maliciously.

A commercial nuclear power plant's reactor is fueled by small ceramic pellets of uranium, roughly the size of the tip of one's little finger. These pellets are placed end-to-end inside hollow metal tubes (made today of zirconium alloy), which are then gas pressurized and welded closed. The filled metal tubes are called fuel rods or pins. Rods are grouped together into fuel assemblies (also known as fuel bundles), typically about 5 to 10 inches square and 12 to 14 feet long, and placed in the reactor core. Depending on the type of reactor, an assembly consists of 36 to 289 rods

and the core contains from 150 to 800 assemblies.[1] An assembly can weigh over half a ton. About every 12 to 18 months, the reactor must shut down for refueling. During this time, about one-fourth to one-third of the fuel assemblies are removed from the reactor core and replaced with new fuel assemblies. Removed assemblies are those that have become too inefficient to power the nuclear reaction (but which have become intensely radioactive and will continue to generate some amount of heat for tens of thousands of years).

When removed from the reactor, spent fuel assemblies are placed in racks in a spent fuel pool. Spent fuel pools are typically 40-foot deep, steel-lined, concrete vaults filled with water. Water is a natural barrier to radiation, and it allows the fuel to cool as it becomes less radioactive. Over the course of years, the spent fuel within the pools has been typically moved or rearranged to accommodate more spent fuel while maintaining safety. At some nuclear power sites, spent fuel has also been transferred to dry storage casks to await permanent disposition at a national repository for spent fuel, such as the deep underground repository planned at Yucca Mountain, Nevada. Spent fuel is typically cooled for 5 years before it can be moved to dry storage casks, which are extremely large and heavy containers made of steel or steel surrounded by additional concrete that can hold from 7 to 68 fuel assemblies. However, the majority of spent fuel at nuclear power plants remains within spent fuel pools. In addition, at a number of nuclear power plants, fuel assemblies have been disassembled or reconstituted[2] due to damaged or leaking fuel rods or for inspection and testing purposes. Disassembly or reconstitution is a delicate process involving heavy machinery. These individual fuel rods and, if broken, rod fragments are also stored in the spent fuel pool, either placed at the bottom or in special containers, repackaged, or in some cases, put back into the parent spent fuel assembly.

This report discusses (1) nuclear power plants' performance in controlling and accounting for their spent nuclear fuel, (2) the effectiveness of NRC's

[1]In the United States, there are two types of nuclear power reactors (boiling water and pressurized water) and several designs for each. With the inclusion of modifications over time, specifications regarding the number and length of fuel rods and the number of assemblies required to fuel a reactor core will vary. Specifications may also be influenced by the type of reactor design.

[2]Reconstitution in this sense refers to the process by which fuel rods are removed from complete fuel assemblies and the replacement of these rods with good ones.

regulations and oversight of nuclear power plants' performance in controlling and accounting for spent nuclear fuel, and (3) actions that NRC is taking in response to licensees' spent fuel control and accounting difficulties. In the context of this report, control and accounting for spent nuclear fuel refers to plants' tracking of and record-keeping for the movement and storage of their spent nuclear fuel. We did not assess plants' safety procedures for the handling or storage of spent fuel or plant security and the vulnerability of spent fuel to theft or terrorist attacks.

To assess nuclear power plants' performance in controlling and accounting for their spent nuclear fuel, we reviewed and analyzed relevant documents, including NRC and nuclear power plant licensees' event reports, NRC studies and investigations of missing fuel rods, and other related documents. We also interviewed NRC and nuclear power plants officials. To assess NRC's material control and accounting requirements for spent fuel stored at nuclear power sites, we reviewed and analyzed relevant regulations, NRC orders and policies, and interviewed NRC and industry officials to identify the key NRC requirements and how they are implemented. To determine how NRC performs oversight of nuclear power plant material control and accounting activities, we reviewed NRC inspection policies, instructions, and reports; analyzed relevant Inspector General reports and internal NRC analyses and studies; interviewed appropriate NRC program and regional officials; and conducted an e-mail survey of all NRC lead/senior inspectors located on site at plants about inspection practices, management controls, and suggestions for improvements, if viewed necessary. To determine the status of NRC actions and plans in response to licensees' spent fuel control and accounting problems, we reviewed internal NRC memoranda, instructions, and reports and interviewed appropriate program officials.

A more detailed description of our scope and methodology is presented in appendix I. More detailed results of our survey of NRC resident inspectors is presented in appendix II. We performed our work between July 2004 and February 2005 in accordance with generally accepted government auditing standards.

Results in Brief

Nuclear power plants' performance in controlling and accounting for spent nuclear fuel has been uneven. Most recently, three nuclear power plants have reported missing or unaccounted-for spent nuclear fuel to NRC. These plants were the Millstone Nuclear Power Station in Connecticut in 2000, the Vermont Yankee plant in Vermont in 2004, and the Humboldt Bay Power

Plant in California in 2004. The Millstone and Vermont Yankee plants are still operating, while the Humboldt Bay plant has been shut down since 1976. The unaccounted-for material from Millstone was never found, while the unaccounted-for material at Vermont Yankee was found 3 months later in its spent fuel pool but in a location other than that indicated by the inventory records. At Humboldt Bay, NRC and licensee officials are still investigating the plant's missing spent nuclear material. In all three cases, the missing spent fuel was in loose fuel rods or segments of fuel rods that had been removed from the fuel assemblies. NRC is also aware of several earlier instances of lost or unaccounted-for spent fuel at other facilities. In 1990, a nuclear power plant shipped one more spent fuel rod than planned. The licensee discovered the discrepancy in 1991, then notified NRC and corrected its records. On several occasions, licensees reported "lost" or "missing" spent fuel but, according to NRC, in each case, the spent fuel was known to be contained within the facility, either in the reactor coolant system, the spent fuel pool, or a refueling pathway. Moreover, information NRC has collected in response to the unaccounted-for spent fuel at Millstone indicates that spent fuel rods outside of fuel assemblies are an issue at additional nuclear power sites. NRC inspectors often could not confirm that containers that were designated as containing loose fuel rods in fact contained the fuel rods. The containers, in some cases, were closed or sealed and, in other cases, the contents were not visible when looking into the spent fuel pool. Thus, spent fuel may be missing or unaccounted for at still other plants.

Although NRC requires plants to maintain an accurate record of all their spent fuel and its location, NRC regulations do not specify how licensees are to conduct physical inventories nor how they are to control and account for loose spent fuel rods and fragments. NRC regulations require licensees to perform a physical inventory at least once every 12 months. However, NRC guidance for material control and accounting does not characterize what constitutes a physical inventory or how to conduct one. Consequently, implementation is inconsistent among the licensees. Physical inventories of spent fuel in spent fuel pools may include anything from comparing a map with the actual assembly racks in the pool to identify misplaced fuel assemblies to performing a comprehensive identification of fuel assemblies according to their serial numbers. Additionally, NRC regulations do not specifically require licensees to track individual fuel rods or fragments, and individual rods, fragments, or other controlled nuclear material may or may not be accounted for in the inventory. Licensees also employed various methods of storing and accounting for this material. In 1988, NRC decided to no longer conduct

routine inspections of plants' compliance with material control and accounting regulations for spent fuel because it considered the potential risk for spent fuel to be lost or stolen from a plant to be very low. According to NRC officials, the agency viewed spent fuel assemblies as "self protecting" because of the extremely high level of radiation they emit and their large size and weight.

In light of the missing spent fuel rods at Millstone and subsequent concerns, NRC is re-assessing its decision to no longer conduct routine inspections of plants' compliance with material control and accounting regulations for spent fuel. For example, NRC is using a three-phase approach under which its inspectors are collecting information on the status of material control and accounting programs at plants. It has also contracted with the Department of Energy's Oak Ridge National Laboratory in Tennessee to review NRC's material control and accounting programs for nuclear materials, including spent fuel. The third phase under which NRC inspectors will collect more detailed information at selected plants will not likely be completed until late in 2005, over 5 years after the spent fuel rods were discovered to be missing at Millstone. However, these efforts, along with the more recent instances of missing spent fuel at Vermont Yankee and Humboldt Bay as well as a 2003 NRC Office of the Inspector General report outlining weaknesses in NRC's oversight of nuclear materials (including spent fuel), have already provided NRC with considerable information on nuclear power plant licensees' control and accounting programs, and NRC officials anticipate that changes in NRC's regulations and oversight activities will be necessary. According to NRC officials, this spring they plan to present the results of the Oak Ridge review and other information to the NRC Commissioners, who will decide whether the agency will take any action.

We are making recommendations to NRC aimed at improving its regulation and oversight of spent fuel by defining how licensees are to conduct physical inventories, specifying control and accounting requirements for loose rods and rod fragments, and taking timely action to monitor licensees' compliance with material control and accounting requirements. In commenting on a draft of this report, NRC generally agreed with the report's conclusions and said that it will develop guidance concerning control and accounting of spent fuel rods and pieces and the conduct of physical inventories. NRC also said that it will revise its existing procedures for inspecting material control and accounting of spent nuclear fuel to include instructions on inspecting control and accounting of rods and pieces. NRC's comment letter is included in appendix III.

Background

NRC is an independent agency established by the Energy Reorganization Act of 1974 to regulate civilian uses of nuclear materials. It is responsible for ensuring that those who use radioactive material—in generating electricity, for experiments at universities, and for other uses such as in construction and medicine—do so in a manner that protects the public, the environment, and workers. NRC has issued licenses to the 103 operating nuclear power plants and the 7 facilities that produce fuel for these plants.[3] In addition, NRC, or the 33 states that have agreements with NRC, regulates about 22,000 other entities that use nuclear materials. For example, in the medical field, nuclear material licensees annually perform millions of diagnostic and therapeutic procedures using radioactive material.

NRC is headed by a five-member commission appointed by the President and confirmed by the Senate. The President designates one commissioner as Chairman and official spokesperson. NRC has over 3,000 employees who work in its headquarters office in Rockville, Maryland, and its four regional offices. NRC is financed primarily by fees it imposes on commercial users of the nuclear material that it regulates. For fiscal year 2005, NRC's appropriated budget of $669 million included approximately $540 million financed by these fees.

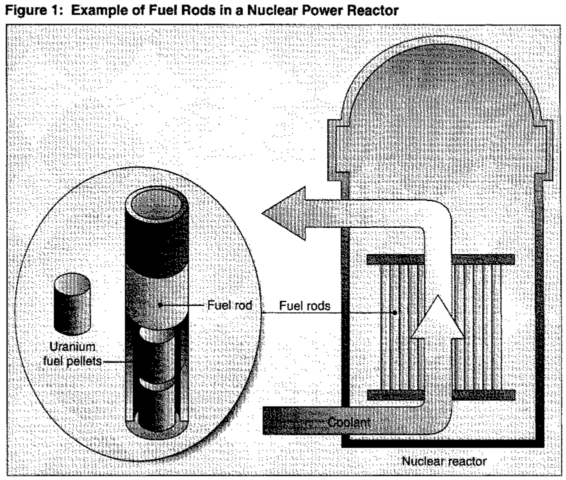
NRC regulates the nation's commercial nuclear power plants by establishing requirements for plant owners and operators to follow in the design, construction, and operation of nuclear reactors. NRC also licenses the reactors and the people who operate them. To ensure that nuclear reactors are operated within their licensing requirements and technical specifications, NRC oversees them by inspecting activities at the plants and assessing plant performance. NRC's inspections consist of both baseline inspections and supplemental inspections to assess particular licensee programs or issues that arise at a particular power plant. Inspections may also occur in response to a specific operational problem or event that has occurred at a plant. NRC maintains from two to three inspectors at every operating nuclear power site in the United States and supplements the inspections conducted by these resident inspectors with inspections conducted by staff from headquarters and/or its regional offices. Generally,

[3]NRC has licensed 104 commercial nuclear power plants to operate. One of these plants has been shut down since 1985. Other nuclear power plants are in the decommissioning phase. These decommissioning plants and a wet storage facility not associated with a nuclear power plant (GE Morris) also still have spent nuclear fuel and are licensed by NRC for these purposes.

inspectors verify that the plant's operator qualifications and operations, engineering, maintenance, fuel handling, security, emergency preparedness, and environmental and radiation protection programs are adequate and comply with NRC requirements. An important part of NRC's regulatory strategy is that licensees have programs that include monitoring, maintenance, and inspection to ensure safe operations.

In addition to the construction and operation of commercial nuclear power plants, NRC regulates the storage, transportation (together with the Department of Transportation), and disposal of spent fuel. Although nuclear power licensees ship a small amount of spent fuel off site for storage and some fuel is stored in dry casks on site, most spent fuel is taken from the reactor and moved directly to the nuclear power site's spent fuel pool.

Figure 1: Example of Fuel Rods in a Nuclear Power Reactor



Source: Nuclear Regulatory Commission.

Spent fuel pools are constructed according to NRC requirements, typically with 4- to 6-foot thick steel-lined concrete walls and floors. Pools are typically 30 to 60 feet long, 20 to 40 feet wide, and 40 feet deep. The location of these pools is dependent on the type of reactor. Essentially, all commercial nuclear power reactors in the United States are one of two types, either a boiling water reactor or a pressurized water reactor.[4] For most boiling water reactors, the pools are located close to the reactors, several stories above ground. For pressurized water reactors, the pools are located in structures outside the reactor building, on the ground or partially embedded in the ground. Regardless of reactor type, these pools are required by NRC to be constructed to protect the public against radiation exposure, even after a natural disaster, such as an earthquake. The water in the pool is constantly cooled and circulated, and the fuel assemblies are generally 20 feet below the surface of the water.

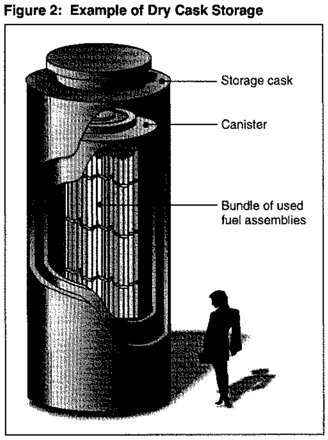
In 1982, under the Nuclear Waste Policy Act, the Congress directed the Department of Energy (DOE) to construct an underground repository for the disposal of spent fuel and other high-level radioactive waste. The Congress amended the act in 1987 and required DOE to only consider Yucca Mountain, Nevada, as a potential site for the repository. In 2002, the President recommended to the Congress, and the Congress approved, Yucca Mountain as a suitable site for the development of a permanent high-level waste repository. For a variety of reasons, DOE is unlikely to open the repository in 2010 as planned.

Lacking a long-term disposal option now, some nuclear utilities must move a portion of their spent fuel into dry storage or face shutting down their plants because their spent fuel pools are reaching capacity. The majority of dry storage facilities are located on site but licensed at a different time from the power plant. These facilities are known as independent spent fuel storage installations, or ISFSIs. Once dry storage is approved by NRC, spent fuel is loaded into dry storage casks, which are steel containers surrounded by additional steel, concrete, or other material meant to provide radiation shielding, and are backfilled with inert gas. The full casks are welded or bolted shut and placed either horizontally or vertically in

[4]A boiling water reactor uses radioactive steam that is generated in the reactor to drive a turbine that generates electricity. The water is returned to the reactor core where it is reheated to steam, driving the turbines as the cycle is repeated. Pressurized reactors send slightly radioactive pressurized water to a steam generator, which creates steam from nonradioactive water kept separated by tubes. The steam drives the turbine and the slightly radioactive water returns to the reactor where it is reheated and the cycle repeated.

concrete vaults or on a concrete pad, depending on the design. Dry storage casks are very large. According to NRC, a vertical cask may be 20 feet tall and 9 feet in diameter and could weigh 125 tons fully loaded. Once in place, the fuel is cooled by air. NRC requires these storage systems to be capable of protecting against radiation exposure and surviving natural disasters. Because the move to dry storage is time consuming and expensive, utilities are, wherever possible, modifying wet pool storage capacity so they can store larger quantities of spent fuel in these pools.

Figure 2: Example of Dry Cask Storage



Source: Nuclear Regulatory Commission.

To ensure that all spent fuel is accounted for and that unauthorized acts such as theft or diversion are detected, NRC regulations require each licensee to (1) establish, maintain, and follow written procedures that are sufficient to enable the licensee to control and account for the material in storage; (2) conduct a physical inventory of the spent fuel; and (3) maintain records of receipt as well as records on the inventory (including location), disposal, and transfer of the material. The physical inventory is required to

be performed at intervals not to exceed 12 months. Compliance with these requirements is a condition of each plant's operating license.

There is a high public perception and fear that spent nuclear fuel, if lost or stolen, could be used maliciously. According to NRC, the control of spent fuel is of great importance because of the potential health and safety implications. However, NRC stated that the very high radiation level of spent fuel makes its theft difficult, dangerous, and very unlikely. NRC also explained that individual spent fuel rods contain only a very small amount of nuclear material, making it unlikely that stolen rods could be used to manufacture a weapon. Theft of many rods would be necessary to acquire enough material to manufacture a weapon. To expose a large number of people to the harmful effects of radiation, the spent fuel would have to be released from its protective containers and dispersed over a wide or densely populated area. Unlike many other hazardous materials, spent fuel is neither explosive nor volatile.[5] Putting the material in a dispersible form would be a difficult and dangerous task involving extensive preparation using special equipment and radiation shielding. In the event of a dispersal, the most significant health effects would involve persons who inhaled very small particles. Such particles would be absorbed into the body and possibly remain there for many years.

According to NRC officials, protective systems at nuclear power reactors are designed using the concept of "defense in depth." The officials pointed out that it is very unlikely that pieces of spent fuel could be out in the public domain because power reactors have layers of protection and controls to detect and prevent spent fuel from leaving the spent fuel pool. Material control and accounting is one of these layers. Physical security, another layer, relies on measures such as portal radiation monitors, fences, guards, locks, and limited access. Additional layers relate to safety. For example, reactors store spent fuel under at least 20 feet of water because of the heat and radiation. If an item of spent fuel is raised out of the spent fuel pool, extremely sensitive detectors in the pool area alarm. The officials said that NRC requires licensees to respond to these alarms and keep records of them. All parties agree that it is very important to fully account for this material.

[5]Spent fuel rods recently discharged from a reactor also contain some radioactive gases that are a by-product of the nuclear fission process—these gases account for a small fraction of the total quantity of radioactive material in spent fuel rods, but because of the short half lives of the material, the gases decay quickly and may not be present in older spent fuel.

Nuclear Power Plants Have Had Unaccounted-For Spent Nuclear Fuel

Three nuclear power plants have recently reported the discovery of missing or unaccounted-for spent nuclear fuel to NRC. These plants were the Millstone Nuclear Power Station in Connecticut in 2000, the Vermont Yankee plant in Vermont in 2004, and the Humboldt Bay Power Plant in California in 2004.[6] NRC's actions in response to the missing or unaccounted-for spent fuel at Millstone led directly to identifying the problems at Vermont Yankee and help identify the problems at Humboldt Bay. In all three cases, the missing or unaccounted-for spent fuel was in loose fuel rods or segments of fuel rods that had been removed from the fuel assemblies. Other plants have also identified possible instances of lost or unaccounted-for spent fuel.

Millstone

At Millstone, two nuclear fuel rods were discovered to be missing when, in November 2000, the licensee, Northeast Utilities, was involved in a records reconciliation and verification effort to support preparations to move spent fuel into dry cask storage. The location of the two full-length fuel rods was not properly reflected in special nuclear material records. The licensee reported that in 1972, a fuel assembly was disassembled after it was removed from the reactor during a shutdown. In 1974 when the fuel assembly was reassembled, two rods that were damaged were not placed back into the assembly. Instead, they were placed in a container for individual rods and stored in the spent fuel pool. Records dated 1979 and 1980 show the individual fuel rods in the container in the spent fuel pool. However, spent fuel pool map records after 1980 do not show either the fuel rods or the container. Records do not indicate what happened to these rods. The licensee's investigations of the loss centered on the significant spent fuel pool activities that occurred between 1980 and 1992, which potentially related to the missing fuel rods. These activities included two re-racks, which modified the racks to accommodate more fuel assemblies, and several shipments to facilities licensed to receive irradiated nonfuel components. The unaccounted-for material from Millstone was never found; the licensee concluded that the rods were shipped to a low-level waste disposal facility in Barnwell, South Carolina. NRC undertook a special inspection to review the licensee's efforts to locate the missing fuel rods and in February 2002 agreed with the licensee that the two missing rods were most likely shipped to the Barnwell facility. In June 2002, NRC

[6]The Millstone and Vermont Yankee plants are still operating, while the Humboldt Bay plant has been shut down since 1976.

took enforcement action against the licensee and fined the licensee $288,000 for failure to adequately account for the special nuclear material contained in the two fuel rods and for failure to report missing material to NRC in a timely manner.

Vermont Yankee

Spent fuel at Vermont Yankee was discovered missing in April 2004, as the NRC resident inspectors at the plant conducted an inspection required by NRC headquarters in response to the lost spent fuel rods at Millstone. The resident inspectors found that although the licensee had been performing an annual physical inventory of the spent fuel pool, the inventory did not verify that two fuel rod segments contained in a special container stored on the bottom of the pool were still present in the container. In responding to the NRC senior resident inspector's questions, the licensee determined that two spent fuel rod pieces, the product of a 1979 fuel reconstitution to replace corroded fuel rods that had failed, were not in the storage location identified in the inventory records. The two fuel rod pieces were approximately one-half inch in diameter by approximately 9 inches and 17.75 inches in length.

The Vermont Yankee licensee formed an investigation team to search for the fuel rod pieces. According to the licensee, the investigation included inspecting the spent fuel pool, reviewing documents, interviewing past and present Vermont Yankee employees, and interviewing contractors that had been associated with spent fuel pool activities and radioactive waste operations at Vermont Yankee. In July 2004, after identifying an aluminum cylinder in the spent fuel pool as potentially containing the two fuel rod pieces, the licensee opened and inspected the cylinder, which in fact contained the two fuel rod pieces. The licensee concluded that the root causes of this event were that (1) the special nuclear material account devices used in inventorying the material had not been properly maintained and (2) the plant's special nuclear material inventory and accountability procedures did not provide guidance for controlling pieces of special nuclear material as they do for whole fuel assemblies. According to a licensee representative, it cost the licensee several million dollars to locate the spent fuel rod pieces and review the plant's material control and accounting procedures and activities to determine the root causes of this incident. The licensee representative also told us that the plant has already taken or is in the process of taking various corrective actions. For example, the plant has revised its material control and accounting procedures to reflect the findings of the root cause analysis.

NRC conducted a special inspection to review the results of the licensee's investigation at Vermont Yankee, assess the licensee's determination of the root cause, determine whether the licensee and its predecessor were in compliance with applicable regulations, and identify which findings or observations may have implications for other nuclear power plants. The inspection was performed from April through August 2004, and a report was issued to the licensee in December 2004.[7] NRC inspectors concluded that the licensee and its predecessor did not keep adequate special nuclear material inventory records of the two spent fuel rod pieces, did not follow the licensee's written procedures when the two spent fuel rod pieces were moved to a fuel storage container, and did not conduct adequate periodic physical inventories of the two spent fuel rod pieces. NRC inspectors also concluded that because the two spent fuel rod pieces remained in the Vermont Yankee spent fuel pool the entire time the apparent violation existed, no actual safety consequence resulted from this apparent violation. Nevertheless, NRC considered the apparent violation a potentially significant failure of the licensee's material control and accounting program. Enforcement action against the licensee for its apparent violation of material control and accounting regulations is currently under review by NRC management. A decision is expected sometime in 2005.

Humboldt Bay

In July 2004, Humboldt Bay officials reported to NRC that in the process of reviewing records and verifying the contents of the spent fuel pool in preparation for dry storage operations, the licensee identified a discrepancy in plant records that questioned the location of three 18-inch fuel rod segments removed from a single spent fuel rod. A plant record from 1968 indicated that the three fuel rod segments were stored in the spent fuel pool in a small container. However, licensee spent fuel shipment records indicated that the entire fuel assembly, including the rod segments, had been sent off site for reprocessing in 1969. The licensee notified NRC of the record discrepancy in the records and the apparent loss of accountability records for the special nuclear material. The licensee implemented a program to search the spent fuel pool for the fuel rod

[7]In June 2004, NRC issued Information Notice 2004-12 to all holders of operating licenses for nuclear power reactors, research and test reactors, decommissioned sites storing spent fuel in a pool, and wet spent fuel storage sites. The notice's purpose was to inform these licensees of the problems at Millstone and Vermont Yankee. Although no specific action or written response was required, NRC indicated that it expected the licensees to review the information for its applicability to their facilities and consider action, as appropriate, to avoid similar problems with their spent fuel inventories.

segments, review additional plant records, and interview plant personnel who were on site during the 1968 to 1969 time period.

In November 2004, NRC officials initiated a special inspection that included a review of the licensee material control and accounting procedures. According to an NRC official, current material control and accounting procedures appear to be adequate, but there were some problems with past accounting practices. The licensee has completed its physical search of the spent fuel pool and other areas of the plant for the three rod segments and has not conclusively identified the missing three 18-inch segments. The licensee is continuing its review of plant records as well as interviewing plant personnel who may have knowledge of the whereabouts of the three fuel rod segments. The licensee issued an interim report of its search results and evaluations at the end of February 2005. NRC plans to issue an interim inspection report after reviewing the licensee interim report. A final inspection report will not be issued until the licensee completes its investigation, currently expected in May 2005.

Other Facilities

Another example of an inaccurately accounted-for fuel rod occurred at a plant that is being decommissioned. The material from its spent fuel pool is being moved to dry cask storage. In 1974, a failed fuel assembly was being disassembled because it was leaking. A fuel rod from this assembly was found to be completely broken in two. The broken rod was supposed to have been put in a fuel rod storage basket in the spent fuel pool. In 1997, an attempt was made to verify the presence of the 16-inch fuel rod segment before the basket was placed into a dry storage cask. The attempt failed, and because the basket was too tall, it was not placed into the dry storage cask at that time. In October 2001, because of the case of the lost fuel rods at Millstone, the licensee decided to again inspect the basket to verify the presence of the fuel rod segment. While the licensee successfully examined the basket, it did not find the fuel rod segment. The licensee undertook a complete review of the site's spent fuel records and concluded that the accounting failure resulted from (1) the poor visual clarity in the spent fuel pool at the time the fuel rod fragment was being placed in the basket and (2) inadequate care by the operators performing the task. The licensee also concluded that the fuel rod segment did not contain any fuel pellets because when the fuel rod broke, the pellets were ejected into the reactor cooling system and ultimately ground into powder. In January 2002, when NRC regional inspectors performed a special inspection at the plant concerning this issue, the inspectors did not take issue with the licensee's conclusions concerning the missing fuel rod. However, they did find that—

since the same procedures were being used at the other operating plants on site—the licensee should examine the fuel assembly and fuel rod storage baskets at these locations to determine that the fuel rods that are supposed to be in them are actually present. In February 2004, NRC inspectors reported that the licensee had inspected the baskets and determined that the existing inventory sheets were correct. NRC closed this matter.

NRC is also aware of additional instances of lost or unaccounted-for spent fuel. In 1990, a nuclear power plant shipped one more spent fuel rod than planned. The licensee discovered the discrepancy in 1991, then notified NRC and corrected its records. On several occasions, licensees reported "lost" or "missing" spent fuel, but, according to NRC, in each case, the spent fuel was actually known to be contained within the facility, either in the reactor coolant system, the spent fuel pool, or a refueling pathway.

The potential exists for missing or unaccounted-for spent fuel rods to be discovered at additional plants. NRC's inspections at plants in response to the Millstone incident revealed that many nuclear power sites (a site may consist of more than one plant) had removed spent fuel rods from fuel assemblies or had reconstituted fuel assemblies.[8] In performing these inspections, NRC inspectors were to obtain from the licensee a list of all irradiated or spent fuel rods that have been removed from their parent assembly. Using the current fuel pool map, the inspectors were to identify the presumed location of the separated rods. Then, by observing from the edge of the pool, the inspector was to answer whether there were rods in all of the locations on the map identified as containing separate rods. At some of these sites, this was not possible. Some containers where rods were presumably stored were closed or their contents were not visible. Even when containers were not closed, some contents were unverifiable because of poor water clarity and lighting and container design. According to NRC officials, the agency has preliminarily chosen these sites for further inspection.

[8]These 70 sites include 65 operating and 4 decommissioning nuclear reactor sites and 1 wet storage site.

NRC Regulations and Oversight Activities Are Insufficient to Ensure Control of All Spent Fuel

Although NRC requires nuclear power plants to maintain an accurate record of their spent fuel and its location, agency regulations do not specify how licensees are to conduct physical inventories of this material nor how they are to control and account for loose or separated spent fuel rods and fragments. In addition, NRC oversight does not include routine monitoring of plants' compliance with its material control and accounting regulations.

NRC Regulations to Control and Account for Special Nuclear Materials Have Several Shortcomings

Under NRC regulations, reactor licensees are required to maintain and follow written procedures sufficiently to enable them to control and account for their special nuclear material. They are to keep records showing the receipt, inventory (including location), disposal, and transfer of all special nuclear material. Each record of receipt, acquisition, or physical inventory of special nuclear material must be retained as long as the licensee has possession of the material and for 3 years following any transfer of such material. Physical inventories of special nuclear material must be performed at least annually. However, NRC guidance for material control and accounting of spent nuclear fuel does not characterize what constitutes a physical inventory nor how to conduct one.

NRC regulations define physical inventory as the means to determine on a measured basis the quantity of special nuclear material on hand at a given time. The regulations also state that the methods of physical inventory and associated measurements will vary depending on the material being inventoried and the processes involved. As a result, licensees implement the physical inventory requirement in different ways. NRC resident inspectors found that inventories may include anything from comparing a map with the assembly racks in the spent fuel pool to performing a comprehensive identification of fuel assemblies according to their serial numbers. For example, at one site, the NRC resident inspector reported that the annual inventory is performed in a "piece counting" manner and does not specifically verify the bundle serial number and fuel pool location. At another site, the NRC resident inspector reported that the annual inventory is only conducted for special nuclear material that has been moved since the last audit. Further, according to an NRC program official, no definition of physical inventory is provided in NRC's regulatory guidance for spent fuel because the concept of physical inventory is a simple "first course in accounting" term. That is, a physical identification of items for the purpose of determining the number of items physically on hand and for comparison with a "book" record, which is the listing of items

according to the accounting records. This NRC official also stated that it's what large retailers do at least once a year, it's a well-understood concept, and it has never been thought to require clarification until now. An NRC resident inspector at still another site told us that the annual physical inventory was an office paperwork review to ensure that all the "i's were dotted and t's were crossed" from past material movements and transfers. The resident inspector added that the licensee had never actually opened its storage container to visually verify the accuracy of the paperwork. In responding to our survey, several resident inspectors suggested that if licensees sealed their containers—for example, with tamper-safe sealing—the containers would not have to be opened during the physical inventory. According to NRC officials, verification of items in spent fuel pools is difficult and time consuming, raises concerns about radiation exposure, and can be costly.

Additionally, although NRC regulations state that licensees are to control and account for all special nuclear material, the regulations do not specifically require licensees to track individual fuel rods or fragments that may be stored in their spent fuel pools. Further, individual rods, fragments, or other controlled special nuclear material may or may not be specifically accounted for in licensees' inventories.[9] As a result, licensees employed various methods of storing and accounting for this material. For example, according to an NRC resident inspector, at one plant the spent fuel rods are in a closed container in a designated area of the spent fuel pool. According to the licensee's procedures, the canister is opened every 6 years and the presence of the correct number of rods is verified. At another plant, the licensee told the resident inspector that it was not sure how many fuel rod fragments are in two storage baskets or how the fragments might be divided up between the baskets. In responding to our survey, several NRC resident inspectors described current practices and offered suggestions for best practices for storing and controlling loose rods and segments. Several respondents described placing loose spent fuel in "dummy" or "skeleton" fuel assemblies, which are empty of fuel, or only in specially designed and approved containers placed in designated cells and racks in the spent fuel pool. In addition, one resident inspector suggested that given that fuel rod breaks are often the result of reconstitution, a best practice would be for the reconstitution of fuel assemblies to be done off site.

[9]Fuel rods may fail for a variety of reasons, such as corrosion or gases leaking from the tubes that hold the rods.

Licensees of nuclear power plants also control and account for their inventories of spent fuel to help meet requirements relating to U.S. treaty obligations for the control of nuclear material. NRC regulations require power reactor licensees to submit a Nuclear Material Transaction Report to the Nuclear Materials Management and Safeguards System every time their facilities receive or transfer special nuclear material or make corrections to their material balances. At least once a year, licensees must also submit to the system material balance reports concerning special nuclear material received, produced, possessed, transferred, consumed, disposed of, or lost, and inventory composition reports. This system, which is managed by the DOE and partially supported by NRC, is operated by a DOE contractor. Because reporting to the system is done in the amount or weight of the nuclear material, such as plutonium, rather than the number of items of spent fuel, nuclear power plant licensees use complex computer programs to provide estimates of the amount of special nuclear material that these items contain. According to plant officials we spoke with, their sites send their annual inventory information to their corporate headquarters to be calculated and reported to the Nuclear Materials Management and Safeguards System contractor.

NRC Does Not Monitor Plants' Compliance with Its Material Control and Accounting Regulations

Since 1988, NRC inspections of power reactor licensees' compliance with material control and accounting requirements have been done on an exception-only basis—that is, if a particular problem or incident was reported by the licensee or identified by NRC that warranted investigating. Since 1988, NRC has not routinely monitored licensee compliance with material control and accounting regulations or verified that licensees' inventories are complete and accurate.

In 1984, NRC's overall inspection program for monitoring nuclear power plants' compliance with their licenses had three parts: (1) a minimum program to be completed at all operating nuclear facilities without exception, (2) a basic program to be completed at all operating facilities, but under some circumstances parts did not have to be completed because of extraordinary demands on limited inspection resources, and (3) a supplemental program of additional inspections to be done on the basis of an assessed need or problems at a facility. According to NRC, the basic program included material control and accounting inspections to be conducted once every 3 years. In 1988, according to NRC officials, this requirement for the periodic inspections of material control and accounting

was discontinued.[10] Officials said that although there is no written documentation available, these inspections were discontinued because spent fuel stored in spent fuel pools was considered to be "self protecting;" that is, the fuel bundles are heavy, highly radioactive, and contained in 40-foot deep pools of water. Spent fuel was viewed as a low-risk danger to public health and the environment and a low priority for use of NRC's resources.

NRC substantially revised its nuclear reactor oversight process in 2000, but did not reinstitute routine material control and accounting inspections. According to NRC, the new process—called the Reactor Oversight Process—uses more objective, timely, and safety-significant criteria in assessing nuclear plant performance. NRC stated that the revised program includes baseline inspections common to all nuclear plants and focuses on activities and systems that are risk significant—that is, those activities and systems that have a potential to trigger an accident, increase the consequences of an accident, or mitigate the effects of an accident. The Reactor Oversight Process also allows for inspections beyond the baseline program if there are operational problems or events that NRC believes require greater scrutiny. Material control and accounting fall under this criteria. When the new process was being developed, NRC officials continued to believe that the material in spent fuel pools was self protecting and that it was appropriate to perform material control and accounting inspections on an exception-only basis. NRC officials told us that there were no indications prior to the discovery of missing fuel rods at Millstone that routine inspections were needed.

According to NRC officials, a few Reactor Oversight Process inspections can indirectly involve NRC inspections of licensees' material control and accounting programs. One of these inspections is of licensee operations during refueling of the reactor. This inspection includes verifying that the location of fuel assemblies is being tracked and that discharged fuel assemblies are placed in permissible locations in the spent fuel pool. To perform such an inspection, NRC inspectors observe the movement of a sample of fuel bundles between the reactor core and the spent fuel pool. NRC officials told us that material control and accounting problems with spent fuel may also be reviewed under plant status inspections. These inspections involve a number of activities surrounding NRC resident

[10]Current NRC officials stated that the 1988 change was made because no problems with material control and accounting for spent fuel had been identified at that time.

inspectors' efforts to be aware of emergent plant issues, potential adverse trends, equipment problems, and other ongoing activities that may impact the plant's safety risks. These efforts include control room walkdowns, attending licensee meetings, and weekly plant tours. Inspectors generally would not learn of material control and accounting problems during one of these inspectors unless the licensee was aware of them and raised them during meetings with the inspectors. In addition, a few NRC resident inspectors that we surveyed mentioned some review of spent fuel records during the loading of dry storage fuel casks.

NRC Is Studying Spent Fuel Control and Accounting Problems but Has Yet to Revise Its Regulations or Oversight Policies

In light of the missing or unaccounted-for spent fuel at Millstone and subsequently at other locations, NRC has various activities under way to assess the need to revise its regulations and oversight of spent fuel. While final completion dates for these efforts have not been set, it will likely be late in 2005 before all of them will be completed. This date would be over 5 years after the spent fuel rods were first found missing at Millstone in 2000. We believe that after the more recent instances of missing spent fuel at Vermont Yankee and Humboldt Bay, the 2003 NRC Office of the Inspector General report outlining weaknesses in NRC's oversight of special nuclear materials (including spent fuel), and information collected during its ongoing efforts, NRC has considerable information that suggests the need to address nuclear power plants' material control and accounting problems, including compliance with NRC regulations. According to NRC officials, they plan to submit the results of these activities to the NRC Commissioners in the spring of 2005. The Commissioners will decide what, if any, actions will be taken in response to the findings.

NRC Is Using a Multifaceted, Phased Approach to Assess the Need to Revise Its Regulations and Oversight

NRC has three principal activities under way to assess the need to revise its regulations and oversight of spent fuel. These are (1) a three-phase project under which NRC inspectors are collecting information on the status of material control and accounting programs at individual plants; (2) a comprehensive program review of NRC material control and accounting programs for special nuclear materials, including spent fuel, through the contract with DOE's Oak Ridge National Laboratory; and (3) a bulletin issued on February 11, 2005, to nuclear power plant licensees requesting information concerning their compliance with NRC material control and accounting regulations.

In November 2003, NRC issued a temporary instruction (TI) to its inspection manual.[11] NRC's overall objective in issuing the TI was to gather site-specific information on nuclear power plants' material control and accounting programs to determine if the issues affecting the missing spent fuel rods at Millstone were present at other power plants. More specifically, NRC wanted to obtain enough information to determine if

- material control and accounting guidance for nuclear power plants should be modified to reduce the possibility of a licensee losing spent fuel rods in the future;
- licensees can account for all spent fuel, including any rods that have been separated from their parent assembly; and
- all items of spent fuel listed in the spent fuel inventory, including rods that have been separated from their parent assembly, can be located in the spent fuel pool.

The TI also called for obtaining site-specific data for the purposes of improving the plants' material control and accounting programs. According to the TI, several inspection activities were aimed at identifying conditions for future program improvement rather than inspections for compliance with regulatory requirements.

NRC is carrying out the TI in three phases. Phases I and II have been completed. In phase I, NRC regional and/or resident inspectors determined if nuclear power plant licensees had ever removed irradiated (spent) fuel rods from an assembly or had reconstituted fuel assemblies. For licensees that had removed rods or reconstituted assemblies, phase II was conducted. During phase II, inspectors used inspections and interviews to fill out a questionnaire about the licensees' material control and accounting programs. Among the questions were the following:

- Does the licensee have a program that tracks individual fuel rods from the point of removal from a fuel assembly to where they are stored in the spent fuel pool and to their final destination?

[11]NRC considers this instruction, *Spent Fuel Material Control and Accounting at Nuclear Power Plants* (Temporary Instruction 2515/154, Nov. 26, 2003), to be temporary because it provides for a one-time inspection and has a short-term expiration date, currently scheduled for November 2005.

- Are there rods in all of the locations identified on the spent fuel map (or equivalent) as containing separated rods? (The inspectors were instructed to obtain from licensees a list of all spent fuel rods that had been removed from their parent assembly and, to the extent possible, answer this question by observing from the edge of the spent fuel pool. If the rods were stored in a closed container, they were to report this under the "Comments" section of the questionnaire.)

- Does the licensee have written material control and accounting procedures approved by licensee management?

- Does the licensee have written procedures for the movement of individual spent fuel rods within the spent fuel pool?

- Does the licensee have procedures for performing oversight of all spent fuel pool operations?

- Does the licensee have records documenting spent fuel pool operations conducted by contractors or fuel vendors?

- Does the licensee perform an annual physical inventory of the spent fuel pool that includes resolution of all discrepancies?

The TI did not specify an approach to answering the questions but instead allowed the resident inspectors to use their best judgment and experience. Our survey of NRC's senior resident inspectors identified some differences in what the inspectors did to answer the phase II questions. The inspectors generally interviewed licensee staff and reviewed licensees' records and written procedures. For the most part, they also used the licensee's map to verify materials in the spent fuel pool. About half used visual tools such as binoculars or underwater cameras to verify materials in the spent fuel pool. About one-fifth observed licensee activities.

Phase III, which has not begun, is to expand on the questions in phase II with more detailed inspection and review of site documentation to verify that procedures or controls are implemented and that they are adequate. For a sample of sites, including those for which "no" was answered to any of the phase II questions, personnel with material control and accounting expertise, rather than the regional and on-site inspectors, are to carry out the activities.

The TI called for phases I and II to be completed within 6 months (by May 2004) and phase III within 18 months (by May 2005). Phases I and II were carried out from January 2004 to May 2004. The phase I review at 70 sites—all 103 operating nuclear power plants at 65 sites (a site may contain more than one nuclear power plant), decommissioning plants at 4 sites, and 1 wet storage facility—identified 65 sites that had removed irradiated fuel rods from an assembly or had reconstituted fuel assemblies.[12] Phase II was conducted for these sites. On the basis of the phase II results, NRC officials determined that at least 19 sites were candidates for more detailed phase III review because NRC inspectors identified that the site had two or more programmatic issues. As of February 2005, NRC officials told us that they are in the planning stages for phase III inspections. Because the TI expires 2 years after its November 2003 issuance, if the phase III inspection were to be performed before this, it would be late 2005 before the project would be completed.

In September 2001, shortly after the terrorist attacks on the World Trade Center and the Pentagon, the Chairman of NRC directed the staff to undertake a comprehensive review of all the agency's safeguards and security programs. NRC contracted with the Oak Ridge National Laboratory in August 2003 to review NRC's material control and accounting programs for special nuclear materials at all NRC licensees. This contract, which according to an NRC official was for about $500,000, was part of a broader NRC effort. The Oak Ridge laboratory, which was chosen because of its expertise in material control and accounting, began the work under the contract in September 2003. Its four principal tasks were to (1) review NRC's current material control and accounting requirements, (2) discuss material control and accounting with current and former employees involved in these activities, (3) visit selected facilities representing different types of special nuclear material licensees to explore current material control and accounting requirements and inspection practices at each site, and (4) develop a report that offers Oak Ridge's views on NRC's material control and accounting requirements across the range of NRC-licensed facilities, discusses any concerns or deficiencies with the current regulations and inspection practices, and provides specific recommendations for programmatic changes. Oak Ridge submitted its report in August 2004 and concluded its work with a management briefing in October 2004. NRC is currently reviewing the report. According to NRC

[12]The phase I review also included decommissioned power plants with wet storage and one wet storage facility.

officials, the staff will complete its review of the report and consider the results of its review, as well as additional recommendations from the staff, in developing a paper to the NRC Commissioners. The paper is due to the Commissioners by spring 2005.

In February 2005, NRC issued a bulletin to holders of operating licenses for nuclear power plants, decommissioning nuclear power plants storing spent fuel in a pool, and wet spent fuel storage sites. The bulletin, which requests information about procedural controls and inventories, responds to issues involving accounting and control of spent (and other irradiated) nuclear fuel, which were first identified at Millstone and then at Vermont Yankee and Humboldt Bay. The purpose of the bulletin is to gather specific information from the licensees about the status of control and accounting of special nuclear material at power reactors and other facilities with wet storage of irradiated fuel. NRC officials told us that results from the bulletin will contribute to assessing the need to revise the current NRC material control and accounting regulations and inspection program. The results from the bulletin will also determine where phase III inspections will be conducted.

NRC Has Considerable Information Indicating Problems with the Control and Accounting for Spent Fuel

The data collected by NRC inspectors during phases I and II of the TI identified material control and accounting problems or shortcomings. Of the sites that had removed fuel rods from their parent assemblies or had reconstituted fuel assemblies, the inspectors reported that some sites did not appear to be in compliance with all of NRC's material control and accounting requirements or otherwise had questionable material control and accounting practices involving procedures, physical inventory, accounting records, or tracking and control.

Additionally, in May 2003, NRC's Office of the Inspector General (OIG) issued its report, *Audit of NRC's Regulatory Oversight of Special Nuclear Materials*.[13] In its report, the OIG concluded that NRC's oversight did not provide adequate assurance that all licensees properly control and account for special nuclear material. The OIG found that NRC performed limited inspections of licensees' material control and accounting activities and could not assure the reliability of the tracking system for special nuclear material. It stated that NRC managers believed that most spent fuel is self-

[13] OIG-03-A-15, May 23, 2003.

protecting from a health and safety point of view and that the risk of undetected loss, theft, or diversion of special nuclear material at power reactors is low. Therefore, according to the OIG, NRC trusts power reactor licensees to implement their material control and accounting activities effectively. The OIG further concluded that without adequate routine inspections of these activities, NRC cannot reasonably ensure that licensees are controlling and fully accounting for special nuclear material. The OIG recommended, among other things, that NRC conduct periodic inspections to verify that licensees comply with material control and accounting requirements, including, but not limited to, visual inspection of licensees' special nuclear material inventories and validation of report information.

In its October 2003 response to the OIG recommendation, NRC said that its staff planned to perform a review of the agency's material control and accounting program (which it did by commissioning the Oak Ridge study) as part of a comprehensive review of the agency's safeguards and security program. NRC added that based on the results of the program review, the staff will determine what changes need to be made to the inspection program. According to NRC's response, any decision to change the inspection program would be made during fiscal year 2005, following completion of the program review. In February 2004, the OIG responded by stating that delaying any decision to make changes to the material control and accounting inspection program until fiscal year 2005 was untimely and did not reflect the importance of ensuring licensee's compliance with material control and accounting requirements. In March 2004, NRC replied that the staff considered the program review to be vital to developing and documenting the regulatory basis for subsequent permanent revisions to the inspection program. An NRC official told us that once the Oak Ridge study has been completed and its findings and recommendations have been addressed, the OIG's recommendation can be closed. The staff currently anticipates that it will develop specific recommendations and submit them to the NRC Commissioners during the spring of 2005.

Conclusions

The effectiveness of nuclear power plants' efforts to control and account for their spent fuel is uneven. A number of plants have experienced instances of missing or unaccounted-for spent fuel, and NRC has identified weaknesses in the material control and accounting programs at various other plants. Contributing to this unevenness is the fact that NRC regulations do not specifically require plants to control and account for loose rods or segments of rods. Although loose spent fuel rods do not

appear to have been a concern when NRC developed its regulations, recent information collected by NRC indicates that most plants have removed rods from their fuel assemblies or reconstituted fuel assemblies. NRC data further indicate that plants are treating loose rods and segments differently under their material control and accounting programs. The absence of specific guidance in NRC regulations for how licensees should conduct physical inventories has also resulted in unevenness in licensees' compliance with these important requirements.

Loose spent fuel rods and rod segments also were not an issue when NRC stopped inspecting licensees' compliance with material control and accounting regulations. Spent fuel was generally viewed in terms of fuel assemblies, which NRC considered to be, in effect, self-protecting because of their high radioactivity and large size and weight. However, individual rods, and especially rod segments, are also highly radioactive and are much smaller and lighter than fuel assemblies. This issue was first raised in 2000, with the loss of spent fuel rods at Millstone. The occurrences of missing or unaccounted-for spent fuel rods and the unevenness in licensees' compliance with material control and accounting requirements highlight the need for more effective oversight of these programs. In the aftermath of terrorist attacks on the United States, material control and accounting of spent nuclear fuel has become more important. Material control and accounting requirements are of great importance because of the potential health and safety consequences of failing to effectively account for and control spent nuclear fuel. While NRC's multifaceted and phased approach to these issues may have been appropriate in the initial context of a single incident at Millstone, waiting longer to make a decision on changes in the agency's regulations and oversight is—as the OIG stated in February 2004—not timely and does not fully reflect the importance of ensuring that licensees comply with control and accounting requirements for spent fuel. We believe that NRC has sufficient information about problems with material control and accounting at nuclear power plants to proceed with revising NRC's regulations and oversight.

Recommendations for Executive Action

To improve the effectiveness of nuclear reactor licensees' material control and accounting programs for spent nuclear fuel, we recommend that the NRC Commissioners take action, in a timely manner, on the following two items:

- Establish specific requirements for the control and accounting of loose spent fuel rods and rod segments and nuclear reactor licensees' conduct of their physical inventories.

- Develop and implement appropriate inspection procedures to verify compliance and assess the effectiveness of licensees' material control and accounting programs for spent fuel.

Agency Comments

We provided a draft of this report to NRC for review and comment. In its written comments (see app. III), NRC generally agreed with the report's conclusions and stated that, overall, the report is well written and balanced. Regarding our recommendation that NRC establish specific requirements for the control and accounting of loose spent fuel rods and rod segments and nuclear reactor licensees' conduct of their physical inventories, NRC stated that it will develop guidance concerning control and accounting of rods and pieces of spent nuclear fuel and the conduct of physical inventories. According to NRC, its current regulations are clear that licensees are required to keep complete records of and conduct annual physical inventories of all special nuclear material, but the implementation guidance does need to be enhanced. Regarding our recommendation that NRC develop and implement appropriate inspection procedures to verify compliance and assess the effectiveness of licensees' material control and accounting programs for spent fuel, NRC said that it plans to revise its existing procedures for inspecting material control and accounting for spent nuclear fuel to include instruction on inspecting control and accounting of rods and pieces.

In addition to comments directly relating to our recommendations, NRC offered a number of comments concerning the report's context. For example, NRC said that its development and issuance of its temporary instruction was postponed by the need to devote NRC's limited resources to areas requiring more immediate attention, especially the comprehensive security and radiological protection activities conducted after the September 11, 2001, terrorist attacks. NRC also said that the report needs to provide balance by giving credit to NRC for making prioritized decisions based on a variety of factors, including, but not limited to, risk of malevolent action, attractiveness of the material for potential malevolent activities, other controls, and available personnel resources. According to NRC, there is no reason to conclude that any of the missing fuel segments were removed for any malevolent purpose. NRC further stated that the report does not make sufficiently clear that the problems at Vermont

Yankee were identified as a direct result of NRC's implementation of its temporary instruction and that implementation of the temporary instruction also helped identify the problems at Humboldt Bay. We believe that our report provides sufficient context for the issues relating to the instances of unaccounted-for spent nuclear fuel. It also devotes considerable attention to describing NRC's actions in response to those instances, including efforts already under way when we began our review. We have added language to the report to emphasize that NRC's actions in response to the Millstone incident led directly to identifying the problems at Vermont Yankee and helped identify the problems at Humboldt Bay. While we also agree that there is no evidence that any of the missing fuel segments were removed for malevolent purposes, we note that it is still not certain what happened to the missing spent fuel at Millstone and Humboldt Bay.

As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of its issuance. At that time, we will send copies of this report to interested congressional committees, the Chairman of NRC, and other interested parties. We will make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staffs have any questions about this report, please call me at (202) 512-3841 or contact me at Wellsj@gao.gov. Key contributors to this report are listed in appendix IV.

Jim Wells

Jim Wells
Director, Natural Resources and Environment

Appendix I

Scope and Methodology

To assess nuclear power plants' performance in controlling and accounting for their spent nuclear fuel, we reviewed and analyzed relevant documents, including Nuclear Regulatory Commission (NRC) and nuclear power plant licensees' event inquiry reports and NRC studies and investigations of missing spent fuel rods. We also interviewed NRC and nuclear power plant officials and conducted two site visits to nuclear power plants. In the context of this report, control and accounting for spent nuclear fuel refers to plants' tracking of and recordkeeping for the movement and storage of their spent nuclear fuel. We did not assess plant safety procedures for handling or storage of spent fuel or plant security and the vulnerability of spent fuel to theft or terrorist attacks.

To assess NRC's material control and accounting requirements for spent fuel stored at nuclear power sites, we reviewed and analyzed relevant legislation, regulations, and NRC orders and policies and we interviewed NRC and industry officials to identify the key NRC requirements and how they are implemented.

To determine how NRC performs oversight of nuclear power plants' material control and accounting activities, we reviewed NRC inspection policies, instructions, and reports; analyzed relevant NRC Inspector General reports and internal NRC analyses and studies; and interviewed appropriate NRC program and regional officials. To determine the status of NRC's actions and plans in response to licensees' spent fuel control and accounting problems, we reviewed internal NRC memorandums, instructions, and reports and interviewed appropriate program officials.

To further explore how NRC performs oversight of control and accounting activities for spent fuel at nuclear power plants, we conducted an e-mail survey of all NRC lead/senior inspectors located on site at the plants about NRC inspection practices, management controls, and the inspectors' suggestions for improvements, if viewed necessary. There are no sampling errors because this was not a sample survey; rather, we sent and received a response from every lead/senior inspector at every site.

Nonetheless, the practical difficulties in developing and administering any survey may introduce errors, commonly referred to as nonsampling errors. For example, difficulties may arise in how a particular question is interpreted or from differences in experiences and information available to respondents when answering a question. We took steps in the development of the survey, its administration, and the data editing to minimize these nonsampling errors. We conducted three pretests of the survey instrument.

The first pretest was with two inspectors at one location by telephone; the second and third pretests were with expert NRC officials, both by telephone. We modified the survey instrument to reflect questions, comments, and concerns received during the pretests. The instrument was also internally reviewed by one of our survey methodologists. In addition, we edited all completed surveys for consistency and contacted NRC inspectors to clarify responses whenever necessary. While our survey responses reflect the opinions of NRC resident inspectors, to ensure the reliability that our survey data was accurate and complete and that spreadsheet calculations were correct, 100 percent of the data entry and all formulas were internally and independently checked and verified.

Through discussions with appropriate NRC officials, we determined in the course of developing our survey that although there are 103 plants currently in operation in the United States, some reactors are colocated on a total of 65 sites. Because only one of the two or three inspectors assigned to each site is designated as the lead NRC authority, we sent our survey to that person. Therefore, we sent our survey to a total of 65 senior/lead NRC inspectors. We expected that given their experience, the lead/senior inspector would obtain additional views and input from the other resident inspectors if they felt it was needed. For example, this additional input would be important if the other inspectors performed the requirements of the temporary instruction for inspection of material control and accounting at nuclear power sites, or if the senior resident was newer to and, therefore, less familiar with the practices and history of the material control and accounting program at the site. We received 67 responses to our survey. In one case, we received a response from the senior inspector and an additional resident inspector at the same site. We kept only the senior inspector's response in our analysis and deleted the other response from that site. In the second instance where we received two responses from one site, special circumstances at that site provided for two senior resident inspectors, but one of those inspectors is primarily responsible for the recovery effort of one of the units at that site. We excluded that inspector's response from our analysis, retaining only the response from the senior inspector with the more general role. This left us with 65 responses for a 100 percent response rate. The detailed results of our survey of NRC resident inspectors are presented in appendix II.

We performed our work primarily in Washington, D.C., between July 2004 and February 2005, in accordance with generally accepted government auditing standards.

Appendix II

Summary Results of GAO Survey of NRC Senior/Lead Resident Inspectors

Overall, we received 65 responses to our survey. Our detailed scope and methodology (Appendix I) contains particulars regarding the development and administration of the survey. Not all of the respondents answered all questions. This may have been a result of either the respondent's choice or they may have been instructed to skip a question according to their previous response. Throughout this appendix, we will note the number of respondents answering each question by noting "n=number of respondents to this question".

Introduction:

The Vermont congressional delegation, along with a member from a nearby Massachusetts district, has asked the U. S. Government Accountability Office to review the NRC's oversight of licensees' material control and accounting program for spent nuclear fuel at commercial nuclear power plants.

As part of our review, we have met with NRC officials in headquarters and at the regional level. We have spent a day touring a nuclear power plant, discussing and reviewing licensee procedures. With this survey, we are gathering information on resident inspectors' activities and views related to this issue. We are distributing the following survey to all NRC senior resident inspectors.

Your contribution to our efforts is gratefully appreciated. The information you provide will assist us in responding to Congressional interest on this important issue.

Please complete and return this survey by November 24, 2004

Instructions:

Simply reply to this email by selecting "Reply to Sender (include message)" and then type in your responses by the return date. Although we are sending this to senior resident inspectors, please feel free to include other resident inspectors at your site in developing your answers. If you do include other inspectors, please provide the contact information of all inspectors contributing to the survey in Question 1.

If you have any questions about this survey or have problems submitting your response, please contact Melissa A. Roye by phone at (202) 512-6426 or by email at RoyeM@gao.gov.

~~~~~~~~~~~~~~~~~~BEGIN SURVEY~~~~~~~~~~~~~~~~~~
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Background Information:

1. In case we would like to clarify any of your responses, please provide the following information for ALL persons involved in submitting information requested in this survey (please copy and paste fields for Respondent 3+, if necessary):

Respondent 1 (n=65)
Name:
Title:
Phone number:
Site Name/Location:
Months at current site:
Months as SRI or RI at any site:
Months at NRC:

Respondent 2
Name:
Title:
Phone number:
Site Name/Location:
Months at current site:
Months as SRI or RI at any site:
Months at NRC:

Material Control and Accounting Related Activities:

2. What did you do to execute the requirements of "Spent Fuel Material Control and Accounting at Nuclear Power Plants," Temporary Instruction (TI) 2515/154? Please mark all that apply. (n=65)

[57] Interviews
[54] Records review
[53] Review of licensee's written procedures
[14] Observation of licensee activities
[49] Verification of materials in the spent fuel pool using a map
[30] Verification of materials in the spent fuel pool using visual aides such as binoculars or underwater cameras
[12] Only Phase I of the TI was completed at this site
[22] At this site, the TI was conducted by someone else. Name of Inspector(s): 22 provided a name and some also included an explanation.
[10] Other? Please explain: 10 provided explanation.

3. Do you routinely inspect or verify the licensee's material control and accounting program policies, records, or procedures for spent nuclear fuel? (n=65)
[23] Yes. *Please elaborate below, if you wish.*
[42] No. *Please elaborate below, if you wish.*
[0] Don't know (*Please go to question 4*).

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Elaboration: Overall, 42 respondents provided an elaboration.
Of that 42, 23 responded yes and 19 responded no.

4. Do you engage in inspection activities under the Reactor Oversight Process (ROP) that indirectly involve material control and accounting for spent fuel? (n=65)
[53] Yes. *Please elaborate below, if you wish.*
[12] No. *Please elaborate below, if you wish.*
[0] Don't know (*Please go to question 5*)

Elaboration: Overall, 53 respondents provided an elaboration.
Of that 53, 49 responded yes and 4 responded no.

5. Do you engage in additional oversight activities (beyond the requirements of the ROP) that aid you in assessing the licensee's abilities for material control and accounting of spent fuel? (n=65)
[14] Yes. *Please elaborate below, if you wish.*
[50] No. *Please elaborate below, if you wish.*
[1] Don't know (*Please go to question 6*)

Elaboration: Overall, 23 respondents provided an elaboration.
Of that 23, 13 responded yes and 10 responded no.

6. Do you think that the NRC should be doing more with regard to the oversight of material control and accounting for spent fuel? (n=65)
[24] Yes. *Please elaborate below, if you wish, and then go to question 7.*
[28] No. *Please elaborate below, if you wish, and then go to question 8.*
[13] Don't know (*Please go to question 8*)

Elaboration: Overall, 38 respondents provided an elaboration.
Of that 38, 20 responded yes, 12 responded no, and 6 responded that they did not know.

7. Would you need more training to perform oversight of the licensee's material control and accounting program? (n=26)
[7] Yes. *Please elaborate below, if you wish.*
[16] No. *Please elaborate below, if you wish.*
[3] Don't know (*Please go to question 8*)

Elaboration: Overall, 13 respondents provided an elaboration.
Of that 13, 5 responded yes and 8 responded no.
In addition, there were 23 respondents who should have skipped this question based on their previous response but chose to answer it anyway. Of that 23, 8 also provided us with further elaboration; 3 responded yes, 3 responded no, and 2 responded that they did not know.

Page 3

8. With regard to the material control and accounting of spent fuel, do you have any best practices or lessons learned to share? For example, the transferring of fuel pellets from broken pins into new pins, the insertion of pins into skeleton assemblies, or any recordkeeping improvements. (n=65)
[14] Yes. *Please elaborate below, if you wish, and then go to question 9.*
[47] No. *Please elaborate below, if you wish, and then go to question 10.*
[4] Don't know (*Please go to question 10*)

Elaboration: Overall, 17 respondents provided an elaboration.
Of that 17, 14 responded yes and 3 responded no.

9. Please indicate if these best practices or policies: (n=12; respondents could check all that could apply)
[9] Are in place at your current site. *Please elaborate below, if you wish.*
[1] Were learned or practiced elsewhere. *Please elaborate below, if you wish.*
[5] Are just something you believe can improve procedures and the oversight process.

Please elaborate, if you wish: 3 respondents provided elaboration. Of those three, all described practices or policies in place at their current site and one respondent stated that it is something they believe can improve procedures and the oversight process.

[1] Other. Please explain: One respondent provided an explanation to discuss a best practice or policy.

10. Please share with us any additional comments: (n=16)

16 respondents provided an elaboration.

~~~~~~~~~~~~~~~~~~~END SURVEY~~~~~~~~~~~~~~~~~~~

Thank you for your participation.

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Comments from the Nuclear Regulatory Commission

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 25, 2005

Mr. James E. Wells, Jr.
Director, Natural Resources
and Environment
U.S. Government Accountability Office
Washington, D.C. 20548

Dear Mr. Wells:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am writing to thank you and your staff for providing us the opportunity to review and comment on your draft report concerning the material control and accounting (MC&A) of spent nuclear fuel. Your willingness to engage the NRC staff throughout the review process is very much appreciated.

Overall, the NRC believes the report to be well written and balanced. Although the NRC generally agrees with the conclusions reached by the U.S. Government Accountability Office (GAO), I would note that significant NRC attention had been redirected to the MC&A area prior to the commencement of the GAO review. The ongoing efforts by the NRC staff to address many of these same issues are worthy of mention.

Prior to September 11, 2001, spent fuel was well protected by physical barriers, armed guards, intrusion detection systems, area surveillance systems, access controls, and access authorization requirements for employees working inside the plants. Since September 11, 2001, NRC has significantly modified its requirements, and licensees have significantly increased their resources to improve security at spent fuel facilities and nuclear power plants. The results of security assessments completed to date clearly show that storage of spent fuel provides reasonable assurance that public health and safety, the environment, and the common defense and security are adequately protected.

The NRC believes that the likelihood that an adversary could steal spent fuel from a spent fuel pool or storage cask is extremely low, given the security and radiation protection measures in place and the ease of detectability and intense, physically disabling radiation from the spent fuel.[1] The actions the NRC has already taken, as well as the actions being taken, are adequate when considered in the full context of power plant security. Consequently, the NRC does not consider the threat of a knowledgeable, active insider stealing a spent fuel rod, or portion thereof, to be credible. The NRC believes that an insider could not overcome the multiple

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[1]The systems and tools used to manipulate spent fuel in pools are designed to prevent an individual from inadvertently raising spent fuel to the surface of the pool, due to the dangerous levels of radiation. Consequently, an insider would have to circumvent specific design features of the tools and equipment, circumvent sensitive radiation detectors surrounding the spent fuel pool, circumvent radiation detectors in the remainder of the plant (e.g., the radiological control boundary), and circumvent radiation detectors at the protected area boundary egress points to remove a spent fuel rod successfully from a reactor site. Further, the sensitivity of these radiation detectors increases as one moves further away from the reactor since these systems are part of the licensee's personnel radiation protection program. Finally, the radiation levels from unshielded spent fuel rods would typically be physically incapacitating within a few minutes and lethal shortly thereafter.

-2-

physical issues and sensitive radiation detectors, both around the pool and throughout the plant associated with preventing the removal of spent fuel rods or pieces from the pool. Furthermore, the physically disabling radiation would prevent an insider from surreptitiously removing the spent fuel from the reactor site for use in a radiological dispersal device (RDD).

As the GAO review indicated, some spent fuel pieces have recently been reported missing or unaccounted for from spent fuel pools; but, for the reasons listed above, there is no reason to conclude that any of the missing or unaccounted for material was removed for any malevolent purpose. Additionally, for all the missing or unaccounted for fuel rods or pieces identified to date, the initiating events occurred decades ago. In response to these events, the NRC has implemented MC&A inspections under the Temporary Instruction (TI) 2515/154, "Spent Fuel Material Control and Accounting at Nuclear Power Plants," issued on November 26, 2003. The NRC is also scheduled to complete the following activities:

- development of guidance concerning control and accounting of rods and pieces;
- development of guidance concerning the conduct of physical inventories; and
- revision of existing procedures for inspecting MC&A of spent nuclear fuel to include instructions on inspecting control and accounting of rods and pieces.

In addition, the NRC plans to conduct additional, more detailed inspections under TI 2515/154 at plants where questions regarding potential weaknesses in MC&A practices still exist. On February 11, 2005, the NRC issued Bulletin 2005-01, "Material Control and Accounting at Reactors and Wet Spent Fuel Storage Facilities," to obtain additional information to assist the staff in deciding which facilities will be selected for these inspections.

In NRC's view, the GAO report does not make sufficiently clear that the problems at Vermont Yankee were identified as a direct result of NRC's implementation of TI 2515/154. Implementation of the TI also helped identify the problems at Humboldt Bay. Although NRC agrees with the report's conclusion that licensees' efforts to account for and control spent fuel are uneven, this knowledge also came from the NRC inspections and responses to the TI, as did the knowledge that the biggest problem is accounting for and controlling pieces of spent nuclear fuel as opposed to assemblies. Additionally, performance-based approaches are often more effective and efficient at achieving the desired outcomes than prescriptive approaches. As a result, dictating how licensees are to meet the MC&A requirements is not necessarily the most effective and efficient approach.

The draft report also stresses the importance of timely action. Providing the broader perspective of overall NRC activities that have occurred since the events of 9/11 is important contextual information. For example, development and issuance of the TI was postponed by the need to devote NRC's limited resources to areas requiring more immediate attention, especially the comprehensive security and radiological protection activities conducted after 9/11.

-3-

With regard to the measures taken by the NRC since issuance of TI 2515/154, the report needs to provide balance by giving credit to NRC for making prioritized decisions based on a variety of factors, including but not limited to, risk of malevolent action, attractiveness of material for potential malevolent activities, other controls, and available personnel resources. Such a context is not present in GAO's report. As noted above, there is no reason to conclude that any of the missing fuel segments were removed for any malevolent purpose. There is an important accounting issue for fuel rod segments, but not a security or safety issue.

Finally, I would like to note that the current regulations (10 CFR 74.19) are clear and do not appear to need revision. Licensees are already required to keep complete records of and conduct annual physical inventories of all special nuclear material. "All special nuclear material" means not only large spent fuel items, but also loose rods and pieces. The NRC agrees that implementation guidance does need to be enhanced to address loose rods and pieces of spent nuclear fuel and the NRC is working to complete the guidance.

As you are aware, the NRC and GAO staffs have had multiple exchanges regarding the report's contents and context. These exchanges have been very beneficial. Should you have questions or concerns on these additional comments, please contact Ms. Melinda Malloy, of my staff at (301) 415-1785.

Sincerely,

Luis A. Reyes
Executive Director
for Operations

GAO Contacts and Staff Acknowledgments

GAO Contacts

Jim Wells, (202) 512-3841
Ray Smith, (202) 512-6551

Staff Acknowledgments

In addition to the individuals named above, Ilene Pollack and Melissa A. Roye made key contributions to this report. Also contributing to this report were John W. Delicath, Doreen Feldman, Judy K. Pagano, Keith A. Rhodes, and Barbara Timmerman.

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PRINTED ON RECYCLED PAPER

STATEMENT OF MARVIN S. FERTEL, SENIOR VICE PRESIDENT AND CHIEF NUCLEAR OFFICER, NUCLEAR ENERGY INSTITUTE

The Nuclear Energy Institute (NEI), on behalf of the nuclear technologies industry, appreciates the opportunity to provide this testimony for the record on the role of nuclear energy in U.S. energy policy, on the value of our 103 operating nuclear power plants, and on the strategic importance of building new nuclear power plants in the years ahead.

NEI is responsible for developing policy for the U.S. nuclear industry. Our organization's 250 member companies represent a broad spectrum of interests, including every U.S. energy company that operates a nuclear power plant. NEI's membership also includes nuclear fuel cycle companies, suppliers, engineering and consulting firms, national research laboratories, manufacturers of radiopharmaceuticals, universities, labor unions and law firms.

America's nuclear power plants are the most efficient and reliable in the world. Nuclear energy is the largest source of emission-free electricity in the United States and our nation's second largest source of electricity after coal. Nuclear power plants in 31 states provide electricity for one of every five U.S. homes and businesses. More than 8 out of 10 Americans believe nuclear energy should play an important role in the country's energy future.[1]

Given these facts and the strategic importance of nuclear energy to our nation's energy security and economic growth, NEI encourages Congress to maintain policies that ensure continued operation of our nation's nuclear plants, and to provide the impetus required to expand emission-free nuclear energy as a vital part of our nation's diverse energy mix.

NEI's testimony for the record will address two major areas:

- The strategic value of America's nuclear power plants as a source of safe, reliable, clean electricity at stable prices, and industry initiatives to ensure continued operation of today's nuclear plants at sustained, high levels of performance, and to prepare for construction of new nuclear power plants.
- The critical importance of stable and efficient regulation of the industry in sustaining safe operation of today's nuclear plant fleet and in building the investor confidence needed to support the next generation of nuclear power plants.

I. THE STRATEGIC VALUE OF NUCLEAR ENERGY

The United States has 103 nuclear reactors operating today. Nuclear power represented 20 percent of U.S. electricity supply 10 years ago, and it represents 20 percent of our electricity supply today, even though we have 6 fewer reactors than a decade ago and total U.S. electricity supply has increased by 25 percent in the period.

Nuclear power has maintained its market share thanks to dramatic improvements in plant reliability, safety, productivity and management. Today's reactors routinely operate at a 90 percent average capacity factor. Improved productivity at U.S. nuclear plants satisfied 20 percent of the growth in electricity demand over the last decade.

Increased output from U.S. nuclear plants in the past 10 years—from 640 billion kilowatt-hours in 1994 to 789 billion kilowatt-hours in 2004—is approximately equivalent to bringing 18 new 1,000-megawatt power plants into service.

Nuclear energy provides several important national benefits.

First, nuclear power plants contribute to the fuel and technology diversity that is the core strength of the U.S. electric supply system. This diversity is at risk because today's business environment and electricity sector market conditions make investment in large, capital-intensive technologies difficult, particularly in advanced nuclear power plants and advanced coal-fired power plants best-suited to supply baseload electricity. More than 90 percent of all new electric generating capacity added over the past 5 years is fueled with natural gas. Natural gas has many desirable characteristics and should be part of our fuel mix, but over-reliance on any one fuel source leaves consumers vulnerable to price spikes and supply disruptions.

Second, nuclear power plants provide price stability that is not available from electric generating plants fueled with natural gas. Intense volatility in natural gas prices over the last several years is likely to continue, largely because of unsustainable demand for natural gas from the electric sector. Such price volatility also subjects the U.S. economy to potential damage. The operating costs of nuclear power plants are stable and can dampen volatility of consumer costs in the electricity market.

[1] Bisconti Research Inc./NOP World, May 2005, 1,000 U.S. adults.

Third, nuclear plants reduce pressure on natural gas supply, thereby reducing costs for other users of natural gas that have no alternative fuel source.

Fourth, nuclear power plants play a strategic role in meeting U.S. clean-air goals and the nation's goal of reducing greenhouse gas emissions. Nuclear power plants produce electricity that otherwise would be supplied by gas- or coal-fired generating capacity. They therefore prevent the emissions that fossil-fuel fired plants would otherwise produce.

The emissions prevented by U.S. nuclear power plants are essential in meeting clean-air regulations. In 2003, they prevented the emission of about 3.4 million tons of sulfur dioxide (SO_2) and about 1.2 million tons of nitrogen oxide (NOx). To put these numbers in perspective, requirements imposed by the 1990 Clean Air Act amendments reduced SO_2 emissions from the electric power sector between 1990 and 2001 by about 5 million tons per year and NOx emissions by about 2 million tons year.[2] Thus, in a single year, nuclear power plants avoid emissions nearly equivalent to those reduced over an 11-year period by other sources.

The NOx emissions prevented by U.S. nuclear plants are equivalent to eliminating NOx emissions from 6 out of 10 passenger cars in the United States. The carbon emissions prevented by nuclear power plants are equivalent to eliminating the carbon emissions from 9 out of 10 passenger cars in the United States. Without nuclear energy, greenhouse gas emissions from the electric power sector would be approximately 30 percent higher. This is significant, since the electricity sector is responsible for approximately one-third of U.S. greenhouse gas emissions.

Finally, nuclear energy is a secure source of energy, and the United States is not alone in recognizing nuclear energy's importance to its energy security, and therefore, national security. The decision to use nuclear power as a major energy source in countries such as France and Japan was based on energy security. The governments of both countries recognized in the 1970s that nuclear energy protects their nations' energy supplies from disruptions caused by political instability and protects consumers from price fluctuations caused by market volatility. France depends on 59 reactors to meet more than three-quarters of its electricity demand, while one-quarter of Japan's comes from its 54 reactors.

Despite strong international commitment to nuclear power, evidenced by the 26 nuclear reactors under construction today around the world, the U.S. nuclear energy sector remains by far the world's largest in terms of electricity production—larger than the nuclear sectors of France and Japan combined.

In summary, nuclear energy represents a unique value proposition. Nuclear power plants provide a tremendous supply of baseload electricity—cleanly, reliably and safely. They provide low-cost electricity for consumers and business today, and serve as a hedge against price and supply volatility. Nuclear plants have valuable environmental attributes, and they help preserve our nation's energy security. These characteristics demonstrate why nuclear energy has strategic importance in U.S. energy policy.

Public support for nuclear energy is at an all-time high due in part to excellent plant safety and performance and growing awareness of nuclear energy's benefits, The industry has monitored public opinion closely since the early 1980s, and two key trends are clear: First, public favorability to nuclear energy has never been higher. Second, there is a 3 to 1 ratio between those who strongly support the use of nuclear energy and those strongly opposed, and that ratio is widening.

A May 2005 survey revealed that 70 percent of Americans favor the use of nuclear energy—the highest level to date. More than 8 in 10 Americans think nuclear power is important for our energy future. Nearly three-quarters of the respondents favor keeping the option to build more nuclear power plants. More than three-quarters said that "electric utilities should prepare now so that new nuclear power plants could be built if needed in the next decade." Six in 10 agree that the United States should definitely build more nuclear plants.[3]

INDUSTRY INITIATIVES TO INCREASE NUCLEAR ENERGY PRODUCTION AND PREPARE FOR NEW NUCLEAR POWER PLANT CONSTRUCTION

Nuclear plants are such valuable electric generating assets that virtually all companies are planning to apply to the Nuclear Regulatory Commission for 20-year extensions to their operating licenses. Companies have renewed the licenses for 32 reactors, formally applied for extensions at 16 reactors and have indicated their intension to file for license renewal at 28 additional reactors. The industry believes that

[2] "EPA Acid Rain Program: 2001 Progress Report," U.S. Environmental Protection Agency, November 2002.

[3] Bisconti Research Inc./NOP World, May 2005, 1,000 U.S. adults.

virtually all U.S. nuclear plants will renew their licenses and operate for an additional 20 years.

In order to maintain safety and reliability, and to prepare the plants for an additional 20 years of operation, the industry is investing in large capital improvement projects, including the installation of new steam generators, new reactor vessel heads and other modifications to increase plant generating capacity.

These capital improvement projects position the plants for many years of operation and demonstrate the industry's commitment to making the capital investments necessary to maintain safety and reliability.

Although it has not yet started to build new nuclear plants, the industry continues to achieve small but steady increases in generating capacity—either through power uprates or refurbishing nuclear capacity that has been shut down. An uprate increases the flow of steam from the nuclear reactor to the turbine-generator so that the plant can produce more electricity. Uprates can increase a plant's capacity up to 20 percent, depending on plant design and how much capital a company is prepared to invest.

Over the past several years, the NRC has authorized power uprates that represent approximately 2,000 megawatts (MW) of additional generating capacity. Over the next 5 years, the NRC anticipates that companies will apply for approximately 30 power uprates, which could add an additional 2,000 MW of new capacity.

In addition, the Tennessee Valley Authority is refurbishing a reactor at its Browns Ferry site in northern Alabama. This is a very complex project—fully as challenging as building a new nuclear plant and it is on schedule and within budget at the midpoint of the project.

However, there are obviously limits on how much additional electricity output the existing nuclear power plants can produce. The Department of Energy projects that by 2025 U.S. electricity demand will increase by 50 percent.[4] Meeting this rising demand will require construction of many new nuclear power plants in the years ahead.

The factors that make operating nuclear power plants a strategic national asset also justify a systematic, disciplined program to build new nuclear power plants in the years ahead to help meet growth in electricity demand, particularly the need for new baseload power plants. In addition to nuclear energy's other benefits, new nuclear plant construction would create thousands of skilled, high-tech jobs—to design and build the plants, manufacture the equipment and fuel, and operate the plants when built. A program of new nuclear plant construction would maintain U.S. technological leadership in this high-tech field.

The nuclear energy industry and DOE launched the Nuclear Power 2010 program several years ago that will aid the industry in building new nuclear capacity when needed, by creating the business conditions under which companies can order new nuclear plants. This is a comprehensive program designed to address the business issues—including licensing and regulatory issues, development of new plant designs, and financing—that could be roadblocks to new nuclear plant construction.

The NRC has developed a new licensing process created as a result the 1992 Energy Policy Act. Under this process, a company or other entity can obtain all necessary regulatory approvals from the NRC before it commits significant capital to a new nuclear power plant. The process allows for advanced site approval, as well as early reactor design approval. And new nuclear plants will receive a single license for construction and operation—not the separate proceedings that created excessive delay in the period between construction and operation of many of today's plants.

This approach should help limit the regulatory risks that delayed construction and licensing in the past. This process also allows meaningful input from the public and other stakeholders, before plant construction, at a time when such input can influence plant design and licensing issues. This should also avoid the costly delays common to the old way of licensing a nuclear plant. Because the old licensing process was a two-step process and did not require all the design and engineering to be complete when the construction permit was issued, it often resulted in lengthy and costly hearings after the plant was built and before it was allowed to operate.

The industry is validating this new licensing process. In 2003, Dominion, Exelon and Entergy initiated a 3-year effort to obtain NRC approval for early site permits. If approved, the permits will allow the companies to "bank" those sites for possible future use, deferring their decision to build reactors until later.

Three industry consortia, consisting of 16 leading energy companies, construction firms, architect/engineers, fuel companies and equipment suppliers, have announced they will demonstrate the process for obtaining a combined construction/operating

[4] "Annual Energy Outlook 2005," Energy Information Administration.

license (COL). The companies, in partnership with DOE, will test the COL process, which will provide a more effective and efficient means of licensing a new nuclear power plant. DOE will share the demonstration costs—obtaining a COL will require a substantial investment of design and engineering work on new nuclear reactor designs. The NuStart Energy consortium last week announced the following locations from which it will select two sites where it will demonstrate the COL licensing process:

- Bellefonte Nuclear Plant in Northeast Alabama, owned by the Tennessee Valley Authority
- Grand Gulf Nuclear Station, Port Gibson, Miss., owned by Entergy Nuclear
- River Bend Nuclear Station, St. Francisville, La., also owned by Entergy
- Savannah River Site, a Department of Energy facility near Aiken, S.C.
- Calvert Cliffs Nuclear Power Plant in Lusby, Md., owned by Constellation Energy
- Nine Mile Point Nuclear Station in Scriba, N.Y., owned by Constellation Energy

The design, engineering and licensing work required before a company orders or builds new nuclear plants represents a substantial investment. Projected costs to complete the licensing demonstrations and the first-of-a-kind design and engineering for one reactor design range from $400 million to $500 million. The industry would expect to share that cost with the Federal Government under DOE's Nuclear Power 2010 program. The private sector would therefore commit the equivalent of $200 million to $250 million to the effort. To carry two new designs forward would require twice that amount from the private sector. Government funding for the DOE Nuclear Power 2010 program is therefore critically important.

The Environment and Public Works Committee has a critical role to play in ensuring that the NRC manages the new licensing processes in a disciplined and efficient manner. This committee can also verify that the NRC provides appropriate guidance to its licensing boards so that any hearing after issuance of the COL but before commercial operation meet the high threshold included in the agency's underlying statute.

The overall objective for this industry initiative is to ensure new nuclear plants can be operational between 2010 and 2020. This will require an aggressive program to complete design, engineering and licensing work before companies can place orders and invest in construction.

At that time, three factors—growth in electricity demand, increasingly stringent environmental controls on coal-fired and gas-fired generating capacity, and continued pressure on natural gas supply and prices—will make construction of new nuclear generation an imperative.

II. THE IMPORTANCE OF A STABLE AND EFFICIENT REGULATORY ENVIRONMENT

Only through a sustained focus on the necessary programs and policies will the industry meet the demand for new emission-free baseload nuclear plants in the 2010 to 2020 timeframe.

As it has in the past, strong congressional oversight will be necessary to ensure certainty and efficiency in the Nuclear Regulatory Commission regulations, ensure effective and efficient implementation of the Federal Government's nuclear energy programs, and maintain America's leadership in nuclear technology development and its influence over important diplomatic initiatives like nonproliferation.

Continued progress toward a Federal used nuclear fuel repository at Yucca Mountain, Nev., is necessary to support nuclear energy's vital role in a comprehensive national energy policy and to support the remediation of DOE defense sites. Since enactment of the 1982 Nuclear Waste Policy Act, DOE's Federal repository program has repeatedly overcome challenges, and challenges remain before the Yucca Mountain facility can begin operation. But as DOE addresses these issues, it is important to keep the overall progress of the program in context.

The consensus of the international scientific community is that a deep geologic repository as envisioned at Yucca Mountain is the best solution for long-term disposition of used military and commercial nuclear power plant fuel and high-level radioactive byproducts. The Bush administration and Congress, with bipartisan support, affirmed the suitability of Yucca Mountain in 2002. Over the past 3 years, the Energy Department and its contractors have made considerable progress toward providing yet greater confirmation that this Federal approach is correct and that Yucca Mountain is an appropriate site for a national repository.

During the past year, Federal courts have rejected significant legal challenges by the state of Nevada and others to the Nuclear Waste Policy Act and the 2002 Yucca Mountain site suitability determination. These challenges questioned the constitutionality of the Yucca Mountain Development Act and DOE's repository system,

which incorporates both natural and engineered barriers to safely contain radioactive material.

In the coming year, Congress will play an essential role in keeping this program on schedule, by taking the steps necessary to provide increased funding for the project in fiscal 2006 and in future years. Meeting DOE's schedule for initial repository operation requires certainty in program funding. This is particularly critical in view of projected annual expenditures that will exceed $1 billion beginning in fiscal 2007.

The industry also believes that it is appropriate and necessary to consider an alternative perspective on the Yucca Mountain project. This alternative would include an extended period for monitoring operation of the repository for up to 300 years after used fuel is first placed underground. The industry believes that this enhanced repository concept would provide ongoing safety assurance and greater confidence that the repository is performing as designed, and it would ensure the protection of the public and the environment. It would also allow DOE to apply evolving innovative technologies at the repository.

Through this approach, a scientific monitoring program would identify additional scientific information to apply in repository performance models. DOE then could update the repository models, and modify design and operations as appropriate.

The industry fully supports the fundamental need for a repository so that used nuclear fuel and the byproducts of the nation's nuclear weapons program are securely managed in an underground, specially designed facility. World-class science by some 3,000 scientists and engineers has demonstrated that Yucca Mountain is the best site for that facility. A public works project of this magnitude will inevitably face challenges. Yet, none is insurmountable. DOE and its contractors have made significant progress on the project as it enters the licensing phase.

The process of licensing the Yucca Mountain facility will require discipline. We encourage the Committee to exercise its oversight responsibility to ensure that the NRC is appropriately staffed and organized, and to ensure that the commission is providing appropriate policy guidance to its staff and hearing boards to conduct an effective and disciplined licensing review.

The radiation standard for the Yucca Mountain project is critical to moving forward. The Environmental Protection Agency's standard was remanded last year by a court ruling. Oversight of EPA by the Committee on Environment and Public Works will be important to ensure that EPA addresses the issues raised by the Court in a responsible manner, consistent with the way our nation regulates other hazardous materials.

If EPA's standard-setting process becomes unduly protracted and threatens significant delays in progress on the Yucca Mountain project, Congress may need to step in to provide guidance and resolve the issue through legislation.

THE NRC REACTOR OVERSIGHT PROCESS HAS PROVEN SUCCESSFUL

Congressional oversight performs an important role in maintaining and encouraging the certainty of the NRC's regulatory process. Such certainty is essential for today's nuclear power facilities and equally critical in licensing new nuclear power facilities. Several years ago, the committee helped encourage the NRC to move toward a new reactor oversight process for the nation's nuclear plants, a process based on quantitative performance indicators and safety significance. Today's reactor oversight process is designed to focus industry and NRC resources on equipment, components and operational issues that have the greatest importance to, and impact on, safety.

The NRC now has 5 years of experience with this revised reactor oversight process. The new approach is successful in improving the transparency, objectivity and efficiency of regulatory oversight. It is an enormous improvement over the agency's previous approach to evaluating nuclear plant safety.

The reactor oversight process combines the results of performance indicators in 18 key areas and findings from about 2,500 hours of NRC inspections per reactor to determine the appropriate allocation of inspection resources across all operating plants. The most recent results, after the fourth quarter of 2004, are as follows:

- 78 reactors had all green (best level) performance indicators and inspection findings and will receive the baseline level of NRC inspection (approximately 2,500 hours per year).
- 21 reactors had a single white (second best level) performance indicator or inspection finding and will receive supplemental inspection beyond the baseline effort.
- 3 reactors had more than one single white indicator or finding in a performance area or had white indicators or findings in different performance areas and will receive more in-depth inspection.

Although an internal NRC report expressed concern about the declining number of “non-green” performance indicators, the industry views this trend as achieving success and a strong example of the soundness of a safety-focused performance-based approach to regulation.

We believe the NRC, the industry and other stakeholders would benefit if the intent of the Reactor Oversight Process were codified through an NRC Policy Statement, drafted by commissioners who provided the policy guidance that established the process. This will be particularly important as changes occur within the NRC staff over the next several years.

THE NEED FOR CONTINUED PROGRESS TOWARD SAFETY-FOCUSED, PERFORMANCE-BASED REGULATION

The industry needs greater certainty both in regulatory processes for today’s plants and in licensing. When the NRC first implemented its new reactor oversight process, few believed that safety-focused regulatory concepts would work. Today, not only do these concepts work, but our plants are safer and more efficient than ever.

During the past 2 years, NRC Chairman Nils Diaz has articulated a sound approach to the future regulatory structure of our industry. He said, “21st century nuclear regulation needs to be anchored in realistic conservatism or conservative realism if we are to avoid the twin pitfalls of underregulation and overregulation.” Such an approach would recognize conservative defense-in-depth regulation informed by science, engineering and nearly 10,000 reactor years of experience worldwide. But achieving a fair, predictable regulatory environment requires the same predictability and realism in plant security and emergency preparedness.

The NRC has begun to incorporate safety-focused insights into Federal regulation. In November 2004, the agency issued 10 CFR 50.69, a new rule that will allow the use of probabilistic risk assessment insights to determine a safety-focused scope of plant components governed by NRC requirements (e.g., quality assurance, monitoring, environmental qualification). In March, a proposed rule was forwarded to the commission that would redefine the limiting pipe-break size used in plant design analyses, based on industry operating experience. When final, this rule would provide both safety and operational benefits.

The commission should be commended for its progress with these initiatives. These rulemakings will not only improve the safety focus of regulations. They will also aid in making the agency’s reactor oversight process more consistent with the regulations, resulting in a more efficient and effective regulatory process.

As the NRC moves to ensure that its regulations are safety-focused and performance-based, the industry sees an urgent need for the NRC to develop an integrated rulemaking plan that shows the committee, and other stakeholders, its plan to transform the existing deterministic regulations into a more effective, safety-focused regime. Such an integrated plan would avoid unnecessary near-term actions that would not be required in a more safety-focused process.

CONGRESS SHOULD REVIEW NRC BUDGET AND STAFFING LEVELS

The NRC’s budget continues to increase significantly. Its fiscal 2006 budget request of $702 million is the highest ever for this agency—a 44 percent increase from its $488 million budget just 5 years ago. The number of full-time-equivalent (FTE) positions at the NRC has increased by more than 13 percent, from 2,785 to 3,154 during the same period. The vast expansion of the agency’s security division and increased staffing for license renewal is largely responsible for this increase.

The NRC’s security division has increased from approximately 30 FTEs to approximately 180 FTEs in just a few years. That increase, in part, was required by a full review of security at nuclear power plants after Sept. 11, 2001, and the subsequent review of plant security plans. Most of those efforts have been completed. In addition, the industry is concerned that the NRC is performing threat analysis and other functions that are duplicative of those funded at the Department of Homeland Security.

The nuclear energy industry acknowledges that budget and staffing increases may be necessary for certain functions at the NRC, as well as to addressing impending work force issues. However, the industry believes that the NRC can be both an effective and efficient regulator, while increasing public safety. For example, the performance demonstrated in the reactor oversight process should provide an opportunity for the NRC to reallocate existing resources. The NRC also should continue to review its regional structure to determine if changes are needed to respond to the continued consolidation in the nuclear industry.

As such, we urge that the committee review the NRC’s structure and management. The industry believes that the NRC would benefit from an independent man-

agement assessment of the agency's needs and plans to meet its organizational and work force challenges.

The NRC's budget request also included a proposal to extend the agency's authority to collect user fees from licensees to fund 90 percent of its annual budget. As the committee is aware, that proposal is an extension of current law. In 2000, this committee passed legislation (S. 1627) that removed up to 12 percent of the NRC's budget from the user fee base to address the fair and equitable assessment of the NRC's fee structure.

As was the case 5 years ago, the NRC continues to provide governmental functions that are related only indirectly to services that are provided to its licensees. As such, it is appropriate that the agency fund a portion of its budget from general revenues. The industry urges the committee to review the appropriate percentage to be recovered from user fees. Also, the industry appreciates the committee's efforts to allow some of the NRC's security functions to be supported by general funds. Functions that are for the common defense of our nation should be funded through general revenues, not a user fee on a specific industry.

The industry further urges the committee to review the current fee structure and identify improvements to be implemented by the NRC. For example, the industry believes that the NRC should directly link activities to fees. We believe it is inappropriate to categorize about 75 percent of the agency's budget in one "general" account, as is the case today.

Finally, the NRC's budget needs to be more transparent and needs to provide more accessible and understandable data. This year's NRC budget, for example, does not provide historical data on overall funding or the number of positions at the NRC. Also, although the NRC budget measures the amount of resources allocated for security, it fails to provide budgetary details on its security division. Without greater transparency and additional data, it is difficult for Congress and stakeholders to analyze how the agency is utilizing its resources.

THE INDUSTRY RECOMMENDS CHANGES TO THE ATOMIC ENERGY ACT

As in previous years, the industry supports changes to the Atomic Energy Act that will facilitate reform of the NRC and its regulatory processes to ensure the effective and efficient regulation of the industry.

If the committee reauthorizes the NRC to recover user fees to offset a portion of its budget, it should remove an appropriate amount for NRC functions that should be supported with general revenues. Those functions, as noted above, should include services that do not directly regulate industry licensees as well as security functions that are the responsibility of the government in providing for the common defense of our nation.

The industry also recommends the following changes to the Atomic Energy Act:

- Congress should repeal Sections 203, 204 and 205 of the Atomic Energy Act to provide the commission with the flexibility and discretion to manage and organize the NRC in the most appropriate manner.
- Congress should remove the restriction on foreign ownership of commercial nuclear facilities.
- When the NRC issues a combined construction and operating license is issued by the NRC for a new nuclear power plant, Congress should clarify that the license term begins when the plant commences operation rather than when the license is issued.
- Congress should remove the requirement that the NRC conduct antitrust reviews as other Federal agencies—notably the Securities and Exchange Commission, the Federal Trade Commission, the Justice Department, and the Federal Energy Regulatory Commission—conduct such reviews.

Noting our reservations regarding the proper offset for the user fee, NEI endorses and supports the provisions included in S. 858, as introduced by Chairman James Inhofe and Sen. George Voinovich. Some of those provisions overlap the above suggestions made on behalf of the nuclear energy industry.

In addition, the industry supports S. 865, also introduced by Chairman Inhofe and Sen. Voinovich. The industry fully supports the 20-year extension of the Price-Anderson Act included in that bill, but given almost 50 years of experience with the Act, and the ongoing oversight authority of the committee, we believe the act should be renewed indefinitely. In addition, we urge the committee to clarify that punitive damages are not available in liability actions covered by the Price-Anderson Act.

The Price-Anderson Act guarantees immediate insurance coverage of more than $10 billion for the public in the case of an extraordinary nuclear occurrence, and this insurance is fully funded by the industry. Taxpayers and the Federal Govern-

ment pay nothing for this coverage. The Price-Anderson Act has provided effective coverage since 1957, and it has been extended by Congress four times.

The Price-Anderson Act has served as a model for legislation in other areas, ranging from vaccine compensation and medical malpractice to chemical waste cleanup. In addition, DOE and the NRC both support extending the Price-Anderson Act. Without extension of the law, no new nuclear power plants could be built to meet growing electricity demand while protecting the nation's air quality.

RADIATION PROTECTION POLICY MUST BE SCIENCE-BASED AND CONSISTENT

As the industry works to increase energy production, it remains committed to maintaining the highest priority on safety. To achieve this goal, it is necessary for the Federal Government to have a uniform radiation protection policy. The policy should be based on the best available science and should be applied equitably and consistently by all Federal agencies.

Duplicative and conflicting regulation by different Federal agencies, using different criteria, must be eliminated. In this area, Federal radiation protection policy falls short. Sen. Pete Domenici requested in 2000 that what is now the Government Accountability Office (GAO) produce a report on this issue. The report, "Radiation Standards: Scientific Basis Inconclusive, and the EPA and NRC Disagreement Continues" (GAO/RCED–00–152), concluded that U.S. radiation protection standards "lack a conclusively verified scientific basis," involve "differing exposure limits" because of policy disagreements between Federal agencies, and "raise questions of inefficient, conflicting dual regulation." A troubling conclusion of the GAO report is that the costs related to complying with such standards "will be immense, likely in the hundreds of billions of dollars" of private and public funds.

This situation has persisted for years, without substantial resolution. For example, former Sen. John Glenn, as chairman of the Senate Governmental Affairs Committee, asked the GAO to report on this issue in 1994. The GAO report, "Nuclear Health and Safety: Consensus on Acceptable Radiation Risk to the Public Is Lacking" (GAO/RCED–94–190), concluded that "differences exist in the limits on human exposure to radiation set by Federal agencies, raising questions about the precision, credibility and overall effectiveness of Federal radiation standards and guidelines affecting public health."

What is particularly troubling is that the 2000 GAO report found that the situation remained essentially unchanged in the 6 years since GAO reported on the issue to Sen. Glenn. Now, 5 years later, the nuclear energy industry notes little substantive progress in resolving the issue of duplicative and conflicting radiation standards.

This situation undermines public confidence in regulatory activities related to radiation and also creates significant uncertainties in projecting costs and schedules of licensing and building new plants, decommissioning of facilities that have closed, and disposal of used nuclear fuel and low-level radioactive byproducts.

Federal radiation protection policy must provide a foundation to protect public health and safety, make the best use of public funding and resources, and help build public trust and confidence in Federal decisions. The current conflicting radiation standards and duplicative regulation work against those principles.

The NRC and Environmental Protection Agency have pursued initiatives to help resolve duplication and conflict in their regulatory programs for radiation safety. The NRC and EPA have agreed on a communication process that addresses their conflicting standards for decommissioning site cleanups. Also, the agencies are coordinating efforts to create a more integrated framework for regulating the safe disposition of low-activity radioactive material and mixed (radiological and chemical) waste.

However, the greatest impediment to resolving issues of duplicative authority and conflicting standards are the various laws that mandate the respective agencies' regulatory programs. Continued oversight will be necessary to ensure that the agencies are achieving consistent radiation protection policy. Ultimately, Congress may be required to resolve through legislation the policy issues that the agencies cannot resolve on their own.

U.S. NUCLEAR POWER PLANTS WERE THE MOST SECURE INDUSTRIAL FACILITIES BEFORE 9/11 AND ARE EVEN MORE SECURE TODAY

The need for regulatory stability in nuclear plant security is particularly important. The NRC and the industry have significantly enhanced security at nuclear power plants. In the three-anda-half years since the Sept. 11 terrorist attacks, the NRC has issued a series of requirements to increase security and enhance training for security programs. The industry has complied—fully and rapidly.

Even prior to September 2001, nuclear power plants were the most secure industrial facilities in the United States. They were built to withstand extreme natural events, such as earthquakes and hurricanes, and the NRC has for more than 20 years required that private security forces defend against an attacking force of saboteurs intent on causing a release of radiation. The facilities are even more secure today, with voluntary and NRC-required security and emergency response enhancements implemented since 2001.

A copy of an NEI fact sheet entitled "Post-Sept. 11 Improvements in Nuclear Plant Security Set U.S. Industry Standard" is attached. It provides additional detail regarding the many security changes that have been made at our plants since September 2001.

In analyzing this changing global environment, the nuclear industry started with the firm knowledge that nuclear power plants—although strongly built, heavily guarded and extremely difficult targets to penetrate—nonetheless are considered by some to be potential terrorist targets. However, as former NRC Chairman Richard Meserve said in 2002:

> It should be recognized that nuclear power plants are massive structures with thick exterior walls and interior barriers of reinforced concrete. The plants are designed to withstand tornadoes, hurricanes, fires, floods and earthquakes. As a result, the structures inherently afford a measure of protection against deliberate aircraft impacts. In addition, the defense-in-depth philosophy used in nuclear facility design means that plants have redundant and separated systems in order to ensure safety. That is, active components, such as pumps, have backups as part of the basic design philosophy. This provides a capability to respond to a variety of events, including aircraft attack.

Meserve noted that the industry's defense-in-depth philosophy includes protection by well-trained, heavily armed security officers; fortified perimeters; and sophisticated intruder detection systems. The industry also assumes that potential attackers may attempt to achieve the help of a sympathetic "insider," so the companies that operate nuclear plants conduct extensive background checks before hiring employees. Even then, to be conservative, our security plans assume that attackers are successful in obtaining insider help.

The nuclear industry has cooperated with the NRC to review nuclear plant security completely, and many improvements have been implemented as a result. Changes include measures to provide additional protection against vehicle bombs, as well as additional protective measures against water- and land-based assaults. The industry has increased security patrols, augmented security forces, added more security posts, increased vehicle standoff distances, tightened access controls and enhanced coordination with state and local law enforcement. The industry is also cooperating fully with the Depaitalent of Homeland Security in its efforts to better protect our critical infrastructure.

In April 2003, the NRC issued new security requirements that revised the agency's "design basis threat," which defines the characteristics of the threat against which the industry must defend and is the foundation for the industry's security programs. Every nuclear power plant submitted a new security plan to comply with the new design basis threat and was required to demonstrate compliance with that plan last October.

In response to considerable congressional concern, the industry has worked with the NRC to develop a revised program to test security at our facilities. This program includes "force-onforce" drills using advanced equipment. Although the tests were suspended for several months after Sept. 11, they are now being conducted at plants nationwide. The NRC observes and evaluates approximately two sets of force-on-force drills per month. At this rate, every plant will conduct NRC-evaluated force-on-force exercises at least once every 3 years, in addition to security exercises conducted by nuclear plants multiple times each year.

The industry has reviewed the recently released study by the National Academy of Sciences (NAS), "Safety and Security of Spent Nuclear Fuel Storage." In response to the NRC actions and the NAS report, nuclear plants are systematically assessing potential augmentation of already redundant safety systems for used fuel pools. The intent is to provide yet greater assurance in the ability to cool used fuel in pools. While the NRC's response to the study indicated that the NRC considers the likelihood of releasing large amounts of radiation to the environment from a spent fuel pool to be "extremely low," the NRC is initiating an independent, site-specific assessment of used fuel pools.

Today, the industry is at the practical limit of what private industry can do to secure our facilities against the terrorist threat. NRC Chairman Nils Diaz and other commissioners have said that the industry has achieved just about everything that

can be reasonably achieved by a civilian force. On March 14, Diaz said "both nuclear security and safety are better than they have ever been and both are getting better. What we have done in the last three and a half years is to make it very difficult for anyone to find ways to attempt acts of radiological sabotage, even more difficult to succeed in doing real harm, and to be very prepared to protect our people in the very unlikely event of radiological release."[5]

The industry believes that the focus of security enhancements should be on those that increase our coordination with DHS and state and local response entities. Security enhancements should also focus on the effective implementation of onsite changes to our security infrastructure and ensure we fully integrate our new security procedures into plant operations. We must ensure they are not interfering with our commitment to safety—our highest priority.

THE INDUSTRY SUPPORTS THE NUCLEAR SAFETY AND SECURITY ACT OF 2005, S. 864

The Nuclear Safety and Security Act of 2005 (S. 864), introduced by Chairman Inhofe and Sen. Voinovich, includes several provisions regarding nuclear plant security. NEI supports those proposals and urges the committee to move the bill to the full Senate for further consideration.

Section 4 of S. 864 is particularly important because it will allow some companies to utilize weaponry that may not be allowed by various state laws. The industry asks that the committee include language to clarify the use of deadly force by nuclear power plant security officers if necessary to protect the plant against terrorist threats. In addition, the industry urges the committee to review and consider legislation that will allow the industry, or the NRC, to have greater access to various Federal data bases.

CONCLUSION

America's nuclear power plants are a critical element of our energy portfolio and a driver of economic growth. Nuclear energy also is vital to our energy security, environmental protection and clean-air goals. The industry continues to operate nuclear plants at exceptional levels of safety and efficiency, and nuclear power plants also are the most secure industrial facilities in the country.

The nuclear industry has significantly increased the amount of electricity that it generates over the past two decades through efficiency improvements and power uprates. But for the nuclear industry to continue generating three-quarters of our nation's emission-free electricity, new nuclear plants must be built. The industry has made great strides to set the stage for new nuclear plant construction and is committed to achieving this objective in the near term.

Nothing is more important to the industry than ensuring that the NRC is an effective and credible regulator. In this regard, the NRC plays an important role in the nuclear energy sector. Achieving the goal of new plant construction depends on a stable regulatory environment, one that assures the safe operation of today's plants and the efficient licensing of new facilities. The NRC has made significant progress toward this end, yet more must be done. Continued oversight by this committee to ensure that the NRC has the appropriate resources, priorities and focus will be critical to achieving these ends.

[5] NRC Chairman Nils Diaz, National Press Club briefing as reported by Agence France-Presse news agency, March 14, 2005.

Fact Sheet: Post-Sept. 11 Improvements in Nuclear Plant Security Set U.S. Industry Standard

November 2004

KEY FACTS

• Nuclear plants are the most secure facilities in the U.S. industrial infrastructure.
• The nuclear energy industry, working with the Nuclear Regulatory Commission, has implemented additional security measures at nuclear facilities since Sept. 11, 2001.
• Recent studies and exercises have confirmed that nuclear facilities are well defended and difficult for terrorists to penetrate.

SETTING THE STANDARD FOR INDUSTRIAL SECURITY

The nuclear industry responded quickly and effectively to the events of Sept. 11. Security at nuclear plants, already the most secure facilities in the U.S. industrial infrastructure, was bolstered and has remained at a heightened level of alert.

Security forces at nuclear plants have increased by 60 percent to approximately 8,000 officers at 64 sites. In addition, the industry has spent an additional $1 billion in security-related improvements since September 2001.

The industry, working with the NRC, instituted additional security measures since Sept. 11, such as:

• extending and fortifying security perimeters
• increasing patrols within security zones
• installing new barriers to protect against vehicle bombs
• installing additional high-tech surveillance equipment
• strengthening coordination of security efforts with local, state and Federal agencies to integrate approaches among the entities—a position the industry continues to support.

Since Sept. 11, the NRC has twice significantly increased the definition of the threat against which nuclear plants must provide protection. As a result, nuclear plants now are able to defend against a greater number of attackers, armed with more weapons than ever before.

In February 2002, the NRC formalized many of the security enhancements that the industry had implemented since Sept. 11. In addition, the orders further restricted access at nuclear plants.

In April 2003, the NRC issued new orders that limit the hours security personnel may work each week. In addition, the NRC increased the training requirements for nuclear plant security officers, including training in weapons proficiency. All U.S. commercial nuclear plants have met these requirements.

Working with the NRC, the industry continues to examine ways to improve security at all U.S. nuclear facilities at every level.

STUDIES CONFIRM STRENGTH OF NUCLEAR PLANT SECURITY

A 2-day national security exercise conducted by the Center for Strategic and International Studies (CSIS) in 2002 found that nuclear plants would be less attractive than other potential targets to terrorist organizations because of the industry's robust security programs. The exercise was designed to explore difficulties and reveal vulnerabilities that might arise in the event of a credible, but ambiguous, threat of a terrorist attack on American soil.

At the conclusion of the exercise, CSIS President John Hamre said that nuclear power plants "are probably our best-defended targets. There is more security around nuclear power plants than anything else we've got."

Peer-reviewed analyses conducted by EPRI, a Palo Alto, Calif.-based research firm, revealed that structures that house the reactor and nuclear fuel facilities would be protected against a release of radiation even if struck by a large commercial jetliner.

State-of-the-art computer modeling techniques determined that typical nuclear plant containment structures used fuel storage pools, fuel storage containers and used fuel transportation containers would withstand a potential impact despite some concrete crushing and bent steel. In all cases, public security would be protected.

More information on NRC security initiatives since Sept. 11 is available at www.nrc.gov.

This fact sheet is also available at www.nei.org, where it is updated periodically.

United States Government Accountability Office

GAO

Testimony

Before the Subcommittee on National Security, Emerging Threats, and International Relations, Committee on Government Reform, House of Representatives

For Release on Delivery
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NUCLEAR REGULATORY COMMISSION

Preliminary Observations on Efforts to Improve Security at Nuclear Power Plants

Statement of Jim Wells, Director
Natural Resources and Environment

G A O
Accountability * Integrity * Reliability

GAO-04-1064T

September 14, 2004

NUCLEAR REGULATORY COMMISSION

Preliminary Observations on Efforts to Improve Security at Nuclear Power Plants

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Accountability·Integrity·Reliability

Highlights

Highlights of GAO-04-1064T, testimony before the Subcommittee on National Security, Emerging Threats, and International Relations, Committee on Government Reform, House of Representatives

Why GAO Did This Study

The events of September 11, 2001, and the subsequent discovery of commercial nuclear power plants on a list of possible terrorist targets have focused considerable attention on the plants' capabilities to defend against a terrorist attack. The Nuclear Regulatory Commission (NRC), an independent agency established by the Energy Reorganization Act of 1974 to regulate the civilian use of nuclear materials, is responsible for regulating and overseeing security at commercial nuclear power plants.

GAO was asked to review (1) NRC's efforts since September 11, 2001, to improve security at nuclear power plants, including actions NRC has taken to implement some of GAO's September 2003 recommendations to improve security oversight and (2) the extent to which NRC is in a position to assure itself and the public that the plants are protected against terrorist attacks. This testimony reflects the preliminary results of GAO's review. GAO will issue a more comprehensive report in early 2005.

www.gao.gov/cgi-bin/getrpt?GAO-04-1064T.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells, (202) 512-3841, wellsj@gao.gov.

What GAO Found

NRC responded quickly and decisively to the September 11, 2001, terrorist attacks with multiple steps to enhance security at commercial nuclear power plants. NRC immediately advised the plants to go to the highest level of security according to the system in place at the time and issued advisories and orders to the plants to make certain enhancements, such as installing more physical barriers and augmenting security forces, that could be completed quickly to shore up security. According to NRC officials, their inspections found that the plants complied with these advisories and orders. Later, in April 2003, NRC issued a new design basis threat (DBT), which establishes the maximum terrorist threat that a facility must defend against, and required the plants to develop and implement new security plans to address the new threat by October 2004. It is also improving its force-on-force exercises, as GAO recommended in its September 2003 report. These exercises are an important agency tool to ensure that the plants' security plans are adequate to protect against the DBT.

While its efforts to date have enhanced security, NRC is not yet in a position to provide an independent determination that each plant has taken reasonable and appropriate steps to protect against the new DBT. According to NRC officials, the facilities' new security plans are on schedule to be implemented by October 2004. However, NRC's review of the plans, which are not available to the general public for security reasons, has primarily been a paper review and is not detailed enough for NRC to determine if the plans would protect the facility against the threat presented in the DBT. For example, the plans GAO reviewed are largely based on a template and often do not include important site-specific information, such as where responding guards are stationed, how the responders would deploy to their defensive positions, and how long deployment would take. In addition, NRC officials are generally not visiting the facilities to obtain site-specific information and assess the plans in terms of each facility's layout. NRC is largely relying on force-on-force exercises it conducts to test the plans, but these exercises will not be conducted at all facilities for 3 years. NRC's oversight of plants' security could also be improved. However, NRC does not plan to make some improvements in its inspection program that GAO previously recommended and still believes are needed. For example, NRC is not following up to verify that all violations of security requirements have been corrected or taking steps to make "lessons learned" from inspections available to other NRC regional offices and nuclear power plants. Moreover, if NRC needs to revise its DBT further as the terrorist threat is better defined, it will need longer to make and test all the necessary enhancements. The Department of Energy, for example, is currently reviewing the DBT for its nuclear facilities.

Mr. Chairman and Members of the Subcommittee:

We are pleased to be here today to discuss our ongoing review of the Nuclear Regulatory Commission's (NRC) efforts to improve security at the nation's 104 commercial nuclear power plants licensed to operate. These plants, which are located at 65 facilities in 31 states, provide about 20 percent of the nation's electricity.[1] We are conducting this review at your request and expect to issue our final report early next year.

The events of September 11, 2001, and the subsequent discovery of commercial nuclear power plants on a list of possible terrorist targets have focused considerable attention on the plants' capabilities to defend against a terrorist attack. However, as you know, NRC is not alone in the challenges it faces to protect against terrorism. Recently, the 9/11 Commission's report highlighted the accomplishments and challenges that remain on many fronts in the nation's fight against terrorism. In recent testimony before this Committee, the Comptroller General applauded the efforts of the 9/11 Commission and discussed its recommendations to improve information sharing and analysis by the intelligence agencies.[2] We have also testified several times before this Subcommittee on weaknesses in border security, federal action needed to address security challenges at the nation's chemical facilities, and the issues faced by the Department of Energy (DOE) in its efforts to secure its nuclear facilities.[3]

To protect commercial nuclear power plants from a terrorist attack, NRC formulates a design basis threat (DBT), which establishes the maximum terrorist threat that a facility must prepare to defend against. The DBT characterizes the elements of a postulated attack, including the number of attackers, their training, and the weapons and tactics they are capable of using. Each facility must prepare a security plan describing its strategy for

[1]More than one nuclear power plant are located at some facilities.

[2]GAO, *9/11 Commission Report: Reorganization, Transformation, and Information Sharing*, GAO-04-1033T (Washington, D.C.: Aug. 3, 2004).

[3]GAO, *Border Security: Additional Actions Needed to Eliminate Weaknesses in the Visa Revocation Process*, GAO-04-899T, (Washington, D.C.: July 13, 2004); GAO, *Homeland Security: Federal Action Needed to Address Security Challenges at Chemical Facilities*, GAO-04-482T (Washington, D.C.: February 23, 2004); GAO, *Nuclear Security: DOE Must Address Significant Issues to Meet the Requirements of the New Design Basis Threat*, GAO-04-701T (Washington, D.C.: April 27, 2004); and GAO, *Nuclear Security: Several Issues Could Impede the Ability of DOE's Office of Energy, Science and Environment to Meet the May 2003 Design Basis Threat*, GAO-04-894T (Washington, D.C.: June 22, 2004).

defending against the threat presented in the DBT. NRC is responsible for reviewing and approving these plans, inspecting the facilities to verify compliance with the plans and other NRC requirements, and conducting force-on-force exercises (mock terrorist attacks) at the facilities to ensure that the facilities' execution of their security plans could repel an attack. NRC considers the DBT and the security plans to be safeguards or sensitive information and does not make them available to the general public.

Our current review is the second on NRC's security program since the September 11 attacks. In our earlier report, issued in September 2003, we made a number of recommendations to NRC to improve its oversight of security at commercial nuclear power plants.[4]

In my testimony today, I will (1) describe NRC's efforts since September 11, 2001, to improve security at nuclear power plants, including actions it has taken to implement some of our September 2003 recommendations to improve security oversight and (2) discuss our preliminary views on the extent to which NRC is in a position to assure itself and the public that its efforts will protect the plants against terrorist attacks. To conduct this work, we reviewed the security advisories and orders NRC has issued to the facilities since September 11, 2001. We also reviewed security documents, such as the DBT and individual facilities' draft security plans,[5] and interviewed NRC security program officials. We did the work reflected in this statement from March 2004 through August 2004 in accordance with generally accepted government auditing standards.

In our final report, we will discuss the extent to which NRC is using a risk management approach to improve security at nuclear power plants. More specifically, we will report on NRC's efforts to (1) define the threat faced by nuclear power plants, (2) identify and characterize the vulnerabilities that would allow a threat to be realized, (3) assess the risks and determine priorities for protecting the plants, and (4) identify the countermeasures to reduce the risk of a successful terrorist attack.

[4]GAO, *Nuclear Regulatory Commission: Oversight of Security at Commercial Nuclear Power Plants Needs to Be Strengthened*, GAO-03-752, (Washington, D.C.: September 4, 2003).

[5]We reviewed 12 of the 65 facilities' draft security plans. According to NRC officials, the plans we reviewed were generally representative of all the plans.

In summary:

NRC responded quickly to the September 11, 2001, terrorist attacks with multiple steps to enhance security at commercial nuclear power plants. For example, NRC

- immediately advised the plants to go to the highest level of security according to the system in place at the time;
- issued a series of advisories and orders to the plants to make certain security enhancements—such as installing additional physical barriers, augmenting security forces, increasing patrols, and further restricting plant access—that could be completed quickly to shore up security until a more comprehensive analysis of the terrorist threat and how to best protect the plants against that threat could be completed;
- issued a new DBT in April 2003 and required the plants to develop and implement—by October 2004—new security plans setting out how the plants will protect against the threat defined in the new DBT. NRC expects the plants will meet this deadline; and
- improved its force-on-force exercises, which are an important agency tool to ensure that the plants are secure, by planning to conduct the exercises every 3 years instead of every 8 years and to make them more realistic, which we had recommended.

While we applaud these efforts, it will take several more years for NRC to make an independent determination that each plant has taken reasonable and appropriate steps to protect against the threat presented in the new DBT. The plants' development and implementation of security plans to comprehensively address the new DBT is a critical step in ensuring that individual plants can defend against terrorism. Although new security plans are to be approved and implemented by October 29, 2004, NRC will not have detailed knowledge about security at individual facilities to ensure that these plans provide this protection. NRC will not have this detailed knowledge, primarily for two reasons:

- First, NRC's review of the new security plans has been rushed and is largely a paper review. NRC is conducting its review of the plans over a 6-month period—as the plants are implementing the plans—and NRC reviewers are generally not visiting the plants to obtain details about the plans and view how the plans interface with the plants' physical layout. For example, the plans do not detail defensive positions at the site, how the defenders would deploy to respond to an attack, or how long the

deployment would take. In addition, NRC is not requesting, and the facilities are generally not submitting for review, the documents and studies supporting the draft security plans.

- Second, it will take up to 3 years for NRC to test implementation of the new plans through force-on-force exercises at all facilities. Moreover, NRC is considering action that could potentially compromise the integrity of the exercises. The agency is planning to require the use of an adversary force trained in terrorist tactics, as we recommended in our September 2003 report. However, NRC is considering the use of a force provided by a company that the nuclear power industry selected; this company provides guards for about half the facilities to be tested. This relationship with the industry raises questions about the force's independence. Furthermore, NRC is not taking advantage of other opportunities to improve the effectiveness of the exercises and its oversight in general by implementing other recommendations from our September 2003 report. For example, NRC is not following up to verify that all violations it found in previous inspections have been corrected and is not taking steps to make "lessons-learned" from inspections available to other regional offices and nuclear power plants, as we had recommended.

In addition to these concerns, we note that NRC's DBT is similar to the DOE's DBT for its nuclear facilities. As you know, in April 2004, DOE officials told this Subcommittee that it would have to revisit its post-September 11 DBT. If NRC also decides to revisit and revise its DBT, NRC will need even longer to put all the necessary security enhancements in place and to test them. Funding the costs of the additional protection could also be an issue. NRC has already stated that the current DBT is the largest reasonable threat against which a regulated private guard force should be expected to defend under existing law. Also, certain potential vulnerabilities, such as airborne assaults, are currently being addressed outside of the DBT. Any changes in this approach to certain vulnerabilities could similarly place additional requirements on the plants.

Background

NRC is an independent agency established by the Energy Reorganization Act of 1974 to regulate the civilian use of nuclear materials. NRC's Office of Nuclear Security and Incident Response, which was established in April 2002, is primarily responsible for regulating and overseeing security at commercial nuclear power plants. This office also develops overall agency policy and provides management direction for evaluating and assessing technical issues involving security at nuclear facilities. In addition, it coordinates with the Department of Homeland Security, the intelligence

and law enforcement communities, DOE, and other agencies on security matters.

NRC begins regulating security at a commercial nuclear power plant when the plant is constructed. Before granting an operating license, NRC must approve a security plan for the plant. If more than one plant is located at a facility, the licensee prepares a physical security plan covering all the plants at the site. Since 1977, NRC has required facilities to have a security plan that is designed to protect against a DBT for radiological sabotage.[6] The DBT characterizes the elements of a possible attack, including the number of attackers, their training, and the weapons and tactics they are capable of using. Since it was first issued in 1977, the DBT has been revised twice, each time to reflect increased terrorist threats. The first revision occurred in 1993 in response to the first terrorist attack on the World Trade Center in New York City and to a vehicle intrusion at the Three Mile Island nuclear power plant in Pennsylvania.[7] The second revision was issued on April 29, 2003, in response to the September 11, 2001, terrorist attacks.

NRC oversees plant security through several activities, particularly security inspections and force-on-force exercises. In annual security inspections at all the plants, inspectors are to check that the plant's security programs meet NRC requirements for access authorization, access control, and response to contingency events. The inspectors also are to review changes to the plant's security plan and self-assessment of security. NRC suspended these inspections in September 2001 to focus its resources on the implementation of security enhancements from NRC's advisories and orders. NRC reinstated the inspection program in early 2004.

NRC began conducting force-on-force exercises under its security inspection program in 1991. The agency suspended these exercises, which were referred to as Operational Safeguards Response Evaluation (OSRE) exercises, after the September 11, 2001, attacks because they considered it

[6]Radiological sabotage against a nuclear power plant is a deliberate act that could directly or indirectly endanger public health and safety by exposure to radiation.

[7]On February 7, 1993, an intruder drove onto the Three Mile Island power plant site, through a gate, and crashed through a roll-up door into the turbine area. The intruder challenged security barriers and disrupted operations for 4 hours before he was apprehended.

unsafe to perform mock attacks during a period of heightened security and because NRC and licenses security resources were focused on responding to the events of September 11, 2001. NRC has conducted some exercises during 2003 and 2004 to gain the information necessary to initiate a revised, permanent force-on-force exercise program sometime in the near future. Although NRC officials have not decided on an exact date, they anticipate that the exercises will resume very soon after the facilities have implemented their security plans, which is scheduled for the end of October 2004.

NRC Actions Since September 11, 2001, to Improve Security at Nuclear Power Plants

Shortly after September 11, 2001, NRC began to respond to the heightened risk of terrorist attacks. Between September 11, 2001, and the end of March 2003, the agency issued over 60 advisories to licensees of nuclear power plants. These advisories recommended enhancements that could be made quickly to shore up security until a more comprehensive analysis of the terrorist threat and how best to protect the plants against the threat could be completed. NRC immediately advised the plants to go to the highest level of security according to the system in place at the time. It followed with advisories and orders designed to increase the size and improve the proficiency of plants' security forces, restrict access to plants, and increase and improve plants' defensive barriers. For example, on October 6, 2001, NRC issued a major advisory, recommending that the licensees take immediate action to increase the number of security guards and to be cautious about using temporary employees.

From October 2001 to January 2002, NRC conducted a three-phase security inspection, checking the facilities to see if they had implemented these advisories. In phase one, NRC inspectors used an NRC-prepared checklist to document the implementation status of NRC's October 6, 2001 advisory. In phase two, security inspectors conducted a more in-depth evaluation of the facilities' implementation of the advisories. During phase three, NRC's security inspectors reviewed each facility's security program to determine if it had complied with the additional measures recommended in the October 6, 2001, advisory. NRC concluded that all facilities were in compliance but that the facilities had not consistently interpreted the recommended measures.

NRC used the results from the three-phase inspection to develop a February 25, 2002, order requiring facilities to implement additional

security measures by August 31, 2002.[8] Many of these measures had been recommended in previous advisories. NRC then conducted security inspections to verify facilities' compliance with all aspects of the order. The inspections were completed in December 2003, and NRC found that all nuclear power facilities were in compliance with the order.

NRC also acted on an item that had been a security concern for a number of years—the use of temporary clearances for temporary employees at the plants. Commercial nuclear power plants use hundreds of temporary employees for maintenance—most frequently during the period when the plant is shut down for refueling. In the past, NRC found instances in which personnel who failed to report criminal records had temporary clearances that allowed them unescorted access to vital areas.[9] In an October 6, 2001, advisory, NRC suggested that facilities limit temporary clearances for temporary workers. On February 25, 2002, NRC issued an order that limited the use and duration of temporary clearances, and on January 7, 2003, NRC issued an order to eliminate the use of temporary clearances altogether. NRC now requires a criminal history review and a background check investigation to be completed before allowing temporary workers to have unescorted access to the power plant.

NRC issued its revised DBT in April 2003 to reflect the post-September 11 terrorist threat. In January 2003, NRC developed a draft DBT that it sent to federal, state, and local law enforcement agencies, federal intelligence and counterintelligence agencies, and the nuclear industry for review and comment. Between January and April of 2003, revisions were made, and the revised drafts were sent for additional comments. On April 29, 2003, NRC issued an order requiring the facilities to protect the power plants from a terrorist attack fitting within the parameters of the new DBT. The new DBT reflected the increased size of a potential terrorist force, the more sophisticated weaponry, and the different methods of deployment demonstrated by the September 11 terrorist attacks. NRC stated that this new DBT was the "largest reasonable threat against which a regulated private guard force should be expected to defend under existing law."

[8] NRC Order EA-02-026.

[9] The vital area, within the protected area, contains the plant's equipment, systems, devices, or material whose failure, destruction, or release could endanger the public health and safety by exposure to radiation. This area is protected by guard stations, reinforced gates, surveillance cameras, and locked doors.

Licensees were given 1 year to develop new security plans based on the new DBT.

At the same time, NRC issued two other orders that (1) limited work hours for security personnel (to 16 hours per 24-hour period, 26 hours per 48-hour period, and 72 hours per week) so that excessive hours would not impair security forces in performing their duties and (2) required enhanced training and qualifications for the plants' security forces. All told, according to the Nuclear Energy Institute,[10] by the end of 2004, the nuclear power industry will have invested about $1 billion in security enhancements since September 11, 2001.

During this period, NRC also developed and strengthened its relations with other federal agencies. It collaborated with the Federal Aviation Administration on protecting airspace over the plants and worked with the Department of Homeland Security, Federal Bureau of Investigation, and local law enforcement agencies to monitor and analyze security threats and to determine additional security measures needed to meet such threats.

NRC has also taken, or is taking, steps to implement our September 2003 recommendations to improve its security inspections and force-on-force exercises. We had recommended that the NRC Commissioners ensure that the agency's security inspection program and force-on-force exercise program are restored promptly. NRC reinstated the security inspection program in February 2004.

NRC has not yet made force-on-force exercises a required activity, as we recommended, but it is taking steps in that direction. During 2003, NRC completed a "pilot" force-on-force program, which included 15 exercises. This pilot program was designed to determine how future force-on-force exercises would be conducted. After completing the 15 pilot exercises, NRC summarized the results in a "lessons learned" document. NRC is now conducting "transition" force-on-force exercises to help it formulate a new, permanent program. Participation in both the pilot and most of the transition exercises was voluntary for the facilities. Only some of the pilot exercises tested the full DBT, and none of the transitional exercises have or will test the full terrorist capabilities of the DBT. NRC officials said that they will not start conducting exercises using the new DBT until

[10]The institute represents licensees of commercial nuclear power plants.

November 2004, after the facilities have implemented their new security plans.

NRC is also making the following additional improvements we recommended for these exercises:

- conducting the exercises more frequently at each site—every 3 years rather than the once every 8 years schedule of the past;
- using laser equipment in all force-on-force exercises to more accurately account for shots fired and to establish a more realistic setting;
- continuing the practice, begun in 2000, of prohibiting licensees from temporarily increasing the number of guards defending the plant and enhancing plant defenses for force-on-force exercises, or requiring that any temporary security enhancements be officially incorporated into the licensees' security plans; and
- requiring the exercises to make use of the full terrorist capabilities stated in the DBT, including the use of an adversary force that has been trained in terrorist tactics.

NRC Cannot Yet Provide Assurances That Its Efforts Will Protect Nuclear Power Plants Against Terrorist Attacks as Outlined in the New DBT

As the principal regulator of commercial nuclear power plants, NRC has an important responsibility to provide an independent determination that each plant is protected against the threat presented in the new DBT. While its efforts to date have no doubt enhanced security, NRC cannot yet provide this determination for three principal reasons. First, its review of the facilities' new security plans setting out how the facilities will respond to the threat presented in the new DBT is not detailed enough. Second, it will not test the effectiveness of all the plans and security at all plants with force-on-force exercises for 3 years, and it does not plan to make some improvements in its security oversight that we believe are needed and have previously recommended. Third, NRC could potentially need to further revise its DBT as the terrorist threat is better defined, which could require changes in the security plans and additional security improvements.

NRC's Review of Security Plans Is Not Detailed Enough to Determine if They Effectively Address the New DBT

NRC's strategy for reviewing the facilities' security plans generally allows for only a document review. While NRC staff originally estimated that it would take 2 years to review the plans, NRC now expects to take 6 months—from April 29, 2004, through October 29, 2004—to review and approve the facilities' security plans. The facilities are also expected to have their plans implemented by that date.

To review the plans in 6 months, NRC assigned 20 NRC staff and contracted for 20 staff from DOE's Idaho National Engineering Laboratory to perform the reviews. The facilities' use of an industry-developed template is also expected to help speed the review.[11] The template was intended to provide standard language for about 80 percent of the plans' contents. However, the plans we reviewed relied almost entirely on the template language and provided little facility-specific information.

Agency officials are generally not visiting the facilities to obtain site-specific information and assess the plans in terms of each facility's particular layout. Since completion of our work, NRC has decided to visit six or seven of the plants to verify information in the plan; however, it will not visit the vast majority of plants. In addition, the plans do not contain much detail. For example, the 12 plans NRC provided for our review do not include information about where responding guards are stationed, where their defensive positions are located, how the responders would deploy to their defensive positions, and how long deployment would take.[12] The plans state that "[p]hysical security measures and specific response protocols for the onsite security force are contained in facility implementing procedures." Also, in all the plans we reviewed, the defensive positions are described only as being established "where necessary." None of the plans we reviewed specified the type of weapons the security forces will carry; stating only that the forces will meet NRC's minimum requirements. According to staff from our Office of Special Investigations with experience in law enforcement and physical security, the security plans are, at best, general guidelines.

The plans often refer to other documents that detail how the requirements will be met and how the plans will be implemented. However, because of the 6-month review time frame, NRC officials do not plan to review these

[11]NRC provided input to the template's development.

[12]Staff from our Office of Special Investigations with experience in law enforcement and physical security assisted in reviewing these plans.

supporting documents as part of their approval process. According to NRC officials, the principal purpose of the plans is to commit the facilities to comply with all NRC security regulations and the template-based plans accomplish that purpose for about 80 to 90 percent of the information.

NRC's Security Oversight Is Limited by Timing of Key Activities and Inaction on Some of Our Recommendations

NRC will not determine the adequacy of the sites' procedures and programs for implementing their security plans and the sites' ability to actually implement the plan until it conducts inspections and force-on-force exercises at the sites. Because NRC plans to annually inspect all sites and conduct force-on-force exercises on a 3-year cycle, it could be 2007 before NRC can say with assurance that all the sites can be protected from a terrorist attack as presented in the new DBT.

In addition to the limitations of the security inspections and the timing of the force-on-force exercises, NRC has not implemented some of the recommendations we made in our September 2003 report to improve its oversight. We recommended that the NRC Commissioners

- require that NRC regional inspectors conduct follow-up visits to verify that corrective action has been taken when security violations, including non-cited violations,[13] have been identified;
- ensure that NRC routinely collects, analyzes, and disseminates information on security problems, solutions, and lessons learned and shares this information with all NRC regions and licensees; and
- enforce NRC's requirement that force-on-force exercise reports be issued within 30 to 45 days after the end of the exercise to ensure prompt correction of the problems noted.

Implementation of these recommendations is needed to correct some important program limitations. For example, during annual inspections, NRC inspectors often classified security problems as non-cited violations if the problem had not been identified frequently in the past or if the problem had no direct, immediate, adverse consequence at the time that it was identified. Instances of a security guard sleeping on duty and a security officer falsifying logs to show that he had checked vital areas and

[13]A non-cited violation is a problem that had not been identified more than twice in the past year or had no immediate, direct consequences at the time it was identified.

barriers when he was actually in another part of the plant, for example, were treated as non-cited violations. This classification tends to minimize the seriousness of the problem. Non-cited violations do not require a written response from the licensee and do not require NRC inspectors to verify that the problem has been corrected. NRC used non-cited violations extensively for serious problems, thereby allowing the licensees to correct the problem on their own without NRC verification of the correction. Consequently, we believe NRC may not be fully aware of the quality of security at a site, and the lack of follow-up and verification reduces assurances that needed improvements have been made.

NRC also has not created a system to share the security problems, solutions, and lessons learned that it finds during security inspections with all the NRC regions and licensees. NRC did create a management review panel that is tracking the regions' findings during the security inspections and the dispositions of the findings. It is also keeping a database of all the findings and dispositions or solutions; however, the database is not accessible by the regions and licensees.

With respect to NRC's enforcement of its requirement for force-on-force exercise reports, NRC officials said they do plan to issue reports when the permanent force-on-force program is reinstated, but the reports will not be made public. During the pilot force-on-force exercises, NRC did not issue any reports, although it prepared a "lessons learned" document for the Commissioners. In addition, an NRC official stated that NRC will not issue reports on the new transitional force-on-force exercises, but will prepare another internal lessons learned document. We continue to believe that NRC needs to promptly issue reports on each exercise to ensure that any security problems are quickly corrected. These reports would also provide the documentation needed to assess trends and patterns among facilities as well as at particular facilities over time.

Finally, although NRC is taking action—as we recommended in our September 2003 report—to establish an adversary force trained in terrorist tactics, NRC is not establishing the force in a manner that provides confidence that the force will be independent and highly trained, and will endeavor to find weaknesses in the facilities' security. NRC delegated the task of establishing the adversary force to an organization—the Nuclear Energy Institute—that represents the licensees of nuclear power plants. The company the Institute selected currently provides security guards to about half of the nuclear power sites to be tested. The company's relationship with the industry raises questions about the force's independence. Of further concern, this company was recently involved in

a controversy over similar tests. During a June 2003 DOE force-on-force exercise at a nuclear site in Oak Ridge, Tennessee, security guards working for this company received uncharacteristically high scores. A subsequent investigation by DOE's Office of the Inspector General indicated that the guards might have cheated on the test and perhaps on many other tests at Oak Ridge, dating back to the mid-1980s. It was alleged that the guards had studied plans for the simulated attacks before they were carried out, had disabled the laser sensors they wore during tests to determine when they were "shot" by mock enemies, arranged trucks and other obstacles to help foil simulated attacks, created special, nonstandard plans to help them perform better on tests, and put more guards on duty at the time of the tests than would normally have been present.

If NRC Needs to Revise Its DBT, Additional Security Enhancements Could Be Required

In April 2004, DOE told this Subcommittee that it would have to review its post-September 11, 2001, DBT for its nuclear facilities to determine if it should be more stringent.[14] If NRC decides, as it gains a better understanding of the terrorist threat, that it also needs to reconsider its DBT, it could take longer to put all necessary enhancements in place and test them with force-on-force exercises. Depending on the additional enhancements needed, funding of the costs of the additional protection and how quickly it could be put in place could also become an issue. NRC previously stated that its April 29, 2003, DBT is the largest reasonable threat against which a regulated private guard force should be expected to defend under current law.

Similarly, NRC is addressing certain potential vulnerabilities outside of the DBT. For example, the terrorists' use of aircraft on September 11 raised questions about nuclear power plants' vulnerabilities to such attacks. According to NRC, although the design of many facilities considered the probability of accidental aircraft crashes that may pose undue risks to public health and safety, only a few facilities were specifically designed to withstand an accidental impact. Nonetheless, NRC believes that nuclear power facilities are among the most hardened industrial facilities in the United States. They are massive structures with thick exterior walls and interior barriers of reinforced concrete designed to withstand tornadoes (and projectiles propelled by tornadoes), hurricanes, fires, floods, and earthquakes. NRC also believes that the efforts to enhance security at

[14] DOE's post-September 11, 2001, DBT, which is similar to NRC's in terms of the threat it outlines, was issued in May 2003. DOE has not yet completed its review of the DBT.

airports and on airplanes and to identify potential terrorists and prevent potential attacks before they occur are an important part of reducing the threat of airborne attacks.

After the September 11 attacks, the Federal Aviation Administration, working with NRC, advised pilots to avoid the airspace above or in proximity to all nuclear power facilities and not to circle in their vicinity. NRC also undertook a major classified research and engineering effort, in conjunction with national laboratories, to evaluate the vulnerabilities and potential effects of a large commercial aircraft's hitting a nuclear power site. This effort includes consideration of additional preventive or mitigating measures to enhance the protection of public health and safety in the event of a deliberate aircraft crash into a nuclear power plant or spent (used) nuclear fuel storage facility. The results are classified and cannot be discussed in this open hearing. According to NRC officials, certain types of aircraft hitting facilities at certain locations pose some risks. The officials noted that, in these cases, the plants would have enough time to take advantage of certain safety features to substantially lessen the risks. NRC officials also believe that the plants would have sufficient time to implement emergency preparedness plans, if necessary.

Airborne assaults on plants remain a public concern. If further consideration of NRC's aircraft study results lead to changes in NRC's approach, the DBT may need to be revised further, again raising questions about the timing and cost of improvements.

In closing, the nation's commercial nuclear power plants are no doubt more secure against a terrorist attack now than they were on September 11, 2001. NRC responded quickly and decisively to the attacks by requiring various enhancements to existing security at the plants. It will be some time, however, before NRC can provide the public with assurances that what has been done is enough. Some of these enhancements are still being put in place, and NRC cannot independently determine that the enhancements will adequately secure the facilities until they have been effectively tested with force-on-force exercises. While our assessment of NRC activities is still underway, we believe that it is important for NRC to act quickly and take a strong leadership role in establishing a worthy adversary team for these exercises, establish priorities for the facilities to be tested, carefully analyze the test results for shortcomings in facility security, and be willing to require additional security improvements as warranted.

Mr. Chairman, this testimony provides our preliminary views. We would be happy to respond to any questions that you or Members of the Subcommittee may have.

For further GAO Contact and Staff Acknowledgements

For further information on this testimony, please contact Jim Wells at (202) 512-3841 or at Wellsj@gao.gov. Raymond H. Smith, Jr.; Kenneth E. Lightner, Jr.; Jill Ann Roth Edelson; Kevin L. Jackson; Carol Herrnstadt Shulman; and Barbara R. Timmerman made key contributions to this testimony.

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SUMMARY OF THE NUCLEAR FEES REAUTHORIZATION ACT OF 2005 (S. 858)

As Introduced by Senators Voinovich and Inhofe on April 20, 2005

FEE REAUTHORIZATION

Nuclear Regulatory Commission User Fees and Annual Charges

A statutory requirement that the NRC recover 90 percent of its costs (minus certain exceptions) through licensee fees would be made permanent. The current fee requirement, imposed by the Omnibus Budget Reconciliation Act of 1990 (42 U.S.C. 2214), is set to expire September 20, 2005. NRC's costs in regulating residual defense radioactive waste under Section 3116 of the Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005 (50 U.S.C. 2601 note) would be excluded from costs subject to the 90 percent cost recovery requirement.

NRC REFORMS

Treatment of Nuclear Reactor Financial Obligations

Funds held to pay for decontamination and decommissioning of nuclear power plants could not be used to satisfy the claim of any creditor under this title until decommissioning was complete. Decommissioning obligations could not be avoided or reduced by any liquidation, reorganization, or other legal proceeding. Nuclear liability insurance premiums held and maintained under the Price-Anderson Act (42 U.S.C. 2210) could not be used to satisfy the claim of any creditor under this title.

Period of Combined License

The initial 40–year period for a commercial nuclear reactor license would begin when NRC authorized the reactor to commence operation after construction had been completed. Currently, under Atomic Energy Act Section 185 b. (added by the Energy Policy Act of 1992, P.L. 102–486), the 40–year initial license period may begin when a "combined construction and operating license" is issued several years before the reactor is to start operating. All previous reactor operating licenses had been issued only after construction was complete, but any future licenses are expected to use the combined license option which was added in 1992.

Elimination of NRC Antitrust Reviews

NRC would no longer have to submit nuclear reactor license applications to the Attorney General for antitrust reviews, as currently required by Atomic Energy Act Section 105 c.

Scope of Environmental Review

In conducting environmental reviews in connection with nuclear power plant license applications, NRC would not have to consider the need for the nuclear plant or potential alternatives.

Medical Isotope Production

Highly enriched uranium (HEU) could be exported to Canada, Belgium, France, Germany, and the Netherlands for production of medical isotopes in nuclear reactors. Those countries would be exempt from existing requirements (under Section 134 of the Atomic Energy Act) that they agree to switch to low-enriched uranium (LEU) as soon as possible and that LEU fuel for their reactors be under active development. Instead, those countries would have to agree to convert to suitable LEU fuel when it became available. NRC would have to review current security requirements for HEU used for medical isotope production and impose additional requirements if necessary. The National Academy of Sciences (NAS) would study the potential availability and cost of medical isotopes produced in LEU reactors. This study would be used by the Department of Energy (DOE) to help determine whether U.S. medical isotope demand could be reliably and economically met with production facilities that do not use HEU. If the Secretary of Energy certified that such demand could be met, the export exemption would be terminated. The current HEU export restrictions are intended to spur foreign cooperation with U.S. efforts to convert all HEU reactors to LEU, but supporters of the exemption contend that the restrictions could disrupt the supply of medical isotopes produced in foreign HEU reactors.

Cost Recovery from Government Agencies

NRC would be authorized to charge cost-based fees for all services rendered to other Federal agencies. Such authority is limited under current law (Atomic Energy Act, Section 161 w.).

Conflicts of Interest Relating to Contracts and Other Arrangements

NRC could enter into contracts with DOE or operators of DOE facilities despite the presence of a conflict of interest if NRC determined that the conflict could not be mitigated and that there was adequate justification for the contract without mitigation.

Hearing Procedures

NRC hearings for nuclear power plant licenses and other purposes would be required to use informal adjudicatory procedures unless NRC determined that formal procedures were necessary to develop a sufficient record or to achieve fairness.

Authorization of Appropriations

Such sums as necessary would be authorized to carry out this title.

HUMAN CAPITAL PROVISIONS

Provision of Support to University Nuclear Safety, Security, and Environmental Protection Programs

NRC would be authorized to provide grants and other assistance to institutions of higher education to support nuclear safety and other fields critical to the NRC mission.

Promotional Items

NRC could purchase promotional items of nominal value to help recruit new employees.

Expenses Authorized to be Paid by NRC

NRC would be authorized to pay transportation, lodging, and subsistence expenses of employees who assist NRC scientific and other staff and are taking higher education courses related to their employment. NRC could also pay health and medical costs of employees and dependents serving in foreign countries.

NRC Scholarship and Fellowship Program

NRC would be authorized to provide scholarships and fellowships for students in fields critical to the NRC mission. Recipients would have to work for NRC for at least as long as the scholarship or fellowship assistance had been provided, unless NRC granted a waiver.

Partnership Program with Institutions of Higher Education

NRC would be authorized to conduct partnership programs to strengthen the ability of historically minority-serving institutions of higher education to teach students and conduct research in fields important to NRC's mission.

Elimination of Pension Offset for Certain Rehired Federal Retirees

When NRC has an emergency need for the skills of a retired employee, NRC could hire the retiree as a contractor and exempt him or her from the annuity reductions that would otherwise apply.

Authorization of Appropriations

Such sums as necessary to carry out this title would be authorized.

SUMMARY OF THE NUCLEAR SAFETY AND SECURITY ACT OF 2005 (S. 864)

As Introduced by Senators Inhofe and Voinovich on April 20, 2005

USE OF FIREARMS BY SECURITY PERSONNEL

Authorizes NRC to allow security guards to possess more powerful weapons (machinegun, semiautomatic assault rifles, etc.) when they are engaged in the protection of NRC-licensed or NRC-certified facilities.

FINGERPRINTING AND CRIMINAL HISTORY RECORD CHECKS

Expands requirements for fingerprinting for criminal history record checks to any individual who is permitted access to safeguards information or unescorted access to an NRC-licensed utilization facility or property subject to NRC regulation.

UNAUTHORIZED INTRODUCTION OF DANGEROUS WEAPONS

Makes unauthorized introduction of weapons into NRC-regulated facilities a Federal crime.

SABOTAGE OF NUCLEAR FACILITIES, FUEL, OR DESIGNATED MATERIAL

Makes it a Federal crime to sabotage commercial nuclear facilities, fuel, and Commission-designated material or property not previously covered by the sabotage section of the Atomic Energy Act.

SUMMARY OF THE PRICE ANDERSON AMENDMENTS ACT 2005 (S. 865)

As Introduced by Senators Voinovich and Inhofe on April 20, 2005

EXTENSION OF INDEMNIFICATION AUTHORITY

Extends Price Anderson liability coverage for an additional 20 years (until 2025).

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